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FIRE RISKS ON TALL OFFICE BUILDINGS.

By Edward Atkinson.

THE merits of the refusal of the Chicago Underwriters to insure the tall office buildings in that city against loss by fire, except at such heavy rates of premium as to forbid owners from making the contract, and thereby putting a stop to the erection of any more very tall buildings of like kind, must as yet be dealt with in a purely hypothetical manner. The writer knows these buildings only from a study of the modes of construction which have been described in print from time to time. In one respect they support a theory which the writer propounded many years ago regarding the construction of isolated factory buildings, to-wit: that the mill should hold up the wall rather than that the wall should hold up the mill. Or, to state the case in clearer terms, it may be held that the frame of a textile factory or large workshop should be put together in a self-sustaining manner like the frame of a ship; then to be covered in by an outer skin or wall on which no vertical stress may come.

If I am rightly informed the tall office buildings under consideration are virtually steel towers veneered with incombustible material. It is very plain that if the inside finish of such buildings is also of incombustible material, including floors, moldings and every other element, then the internal hazard will consist only in the possible combustion of office furniture, books, papers and other like contents. Such hazard would be a perfectly suitable one for an insurance company to take at a very moderate rate of premium, but the unknown element in the case is the outside exposure.

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These buildings are surrounded by others more combustible, which, when ignited, will develop an intense heat.

Any one who has ever witnessed the rapid spread of a great fire may well doubt the resistance of a steel building guarded only with a thin veneer of non-heat-conducting material. In the great Boston fire the writer witnessed the spread of the flames to windward across a street one hundred and twenty feet wide in such a manner as would utterly forbid him from ever granting a policy upon a tall office building constructed in the manner described, which might be exposed to the heat generated by the combustion of a warehouse of ordinary construction in close proximity to it. The instances of the complete destruction of so-called fire-proof factories, store-houses, wheat elevators and other buildings composed mainly of iron and brick are so numerous as to have given underwriters a profound distrust of iron or steel unless so thickly encased with non-heat-conducting material as not to be liable to be heated to the point of dangerous expansion.

It may be assumed that the skillful inspectors who have rated the tall office buildings are not satisfied on this point and whether it is possible for a steel frame to hold up the quantity of non-heat-conducting material which would be necessary for its full protection is, to say the least, a very doubtful question. The experience of the factory mutual companies is adverse to very tall buildings, and they prefer to cope with wide floor areas rather than with height. In connection with the matter some consideration of a more general nature may be timely.

The mutual factory companies long ago comprehended the greater danger in textile factories and other buildings of like kind of many stories in height, and therefore both for reasons of safety, stability and freedom from fire, and also for the more convenient placing and economic working of machinery, few textile factories are now built above four stories in height including the basement, except under some very peculiar conditions where additions to existing establishments control the method and height.

On the other hand, the tendency to construct such factories of an extreme width has been checked for the reason that in case of fire it is futile to expect streams of water to be thrown horizontally from the side towards the center of a mill more than fifty to sixty feet from each side of the factory, so as to cover one hundred to one hundred and ten feet of horizontal distance.

Under these conditions the carding and spinning departments

of textile factories are now customarily provided for in buildings of three or four stories in height, not exceeding one hundred and ten feet in width, and of such length as may be suitable to the amount of machinery which is to be placed in them on each floor, say from four hundred to eight hundred feet in length, occasionally even more. The looms or weaving departments are being placed more and more in one-story buildings, commonly called "weaving sheds," which are lighted in part from above.

It therefore becomes necessary for the factory underwriters to deal wholly with buildings which are not very high, but of which the floor areas are very large, very often 40,000, sometimes 80,000, occasionally 120,000 square feet on one floor. In order to reduce the danger of loss to the minimum such buildings are therefore constructed with no open ways through any floor in the mill proper, either for the passage of persons or stock; in later practice not even for belts or pipes. The stairways and elevator shafts are carried in towers or compartments which are guarded by fire-doors in their connection with the mill proper, which are customarily fitted overhead with a skylight covered with very thin glass that will break when very slightly heated, thus giving a vent to flame and smoke in the event of a fire occurring in any part of the mill finding access to either shaft. Belts are now carried in belt-towers without openings into the mill except sometimes by small doorways guarded by double fire-doors—only the shafting passing from the belt-tower to the several rooms on properly-adjusted bearings in the walls without any open space around the pillow-blocks.

When partitions are necessary or expedient they are put up transversely over any line of beams; some of the materials which can now be used being so light as not to deflect a beam in any injurious manner, though capable of resisting a fire as long as a thick plank floor. Partitions around occasional stairways in mills proper require to be guarded or placed so that the fire-door may be at the foot of each stairway rather than at the head and so that there shall be no obstruction to hose streams in the room above. In this manner the vertical extension of fire is prevented so far as it may be possible in the methods of planning and construction.

According to my observation of very many high buildings, and also of very many buildings of wide floor areas in cities, safeguards against loss are almost wholly disregarded in the customary plans and methods of construction. It sometimes seems as if human ingenuity had been exhausted in planning the buildings so

as to assure complete destruction from the smallest cause. This is especially noticeable in large warehouses filled with open stocks of goods and in what purport to be stone churches.

In very many other very solid buildings, of which the main elements are well devised and which ought not to be exposed to any considerable hazard from the combustion of any part of the building itself, every consideration of fire appears to have left the mind of the owner, builder and architect when dealing with the finish of the building. I can designate well-constructed brick and iron buildings in which the iron beams and posts are sometimes well protected from the direct exposure to heat but are more often exposed, but which have been finished for occupation :

First, by the construction of combustible wooden dados on the walls, which are wholly out of place.

Second, by sheathing the walls with very combustible fine wood fastened solidly against the brick work.

Third, by heavy combustible wooden moldings or frames around the doorways, in which wooden doors are placed.

Fourth, by setting up extensive light wood partitions of pine and glass of the most combustible kind, through many parts of the building.

Fifth, by enclosing open stairways built of wood in wooden partitions.

Sixth, by conducting a fire-proof elevator well into an open space between it and the upper ceiling which is hung two or three feet below the roof, without a skylight or vent from the elevator ; thus rendering it absolutely certain that if any fire should get up that elevator-shaft it will destroy the roof and probably destroy the building.

Lastly, the building being thus supplied with light wood in sufficient measure to tear any building to pieces by expansion when the wood is fully ignited, this wood-work is finished with the most combustible turpentine varnishes, over which a fire runs with the speed of a race-horse, assuring its rapid ignition.

I once computed the heat units in the many cords of pine wood partition, sheathing, etc., in what purported to be a slow-burning warehouse of heavy mill construction and I found that it would have sufficed to supply charcoal enough to melt a large charge of pig-iron in a puddling furnace.

It thus happens that one often finds in the papers a record of the complete destruction by fire of what had been called either a

fire-proof building, or a building of so-called mill construction, or a slow-burning building free from hollow spaces and free from many of the faults which infest the common examples of combustible architecture—merely because the same foresight which had been exercised in the main elements of construction had been lost in dealing with the finish. All these causes of danger are very prevalent, even in buildings which might be wholly safe from the rapid combustion of any part of the building itself, if common sense had been applied to the finish.

It therefore follows that the true question of safety does not consist wholly either in limiting the height, or the number of stories, or the width and length of floor areas. Each of these elements must be dealt with, *in connection with the method of finishing*, and even then the final consideration must be given to the proposed use or contents of such buildings. Until all these elements have been carefully considered and until specific rules have been established in regard to each and all the elements that I have named, no absolute conclusion can be reached either in respect to height, number of stories, or area of floor, so far as the danger of loss by fire is concerned.

Again, when all points in respect to height and area have been determined, much will depend upon the construction of the neighboring buildings. Whether or not an iron or a steel building faced on the outside and even on the inside with incombustible material will stand the excessive heat that may sometimes be thrown upon it from a neighboring fire, will depend wholly upon the resistance to heat of the substance with which the iron or steel is guarded and the manner in which it has been attached thereto. I have in mind that in at least one instance a brown-stone building of good construction has been destroyed by the heat of a fire on the opposite side of the way, expanding the iron roof to such an extent that it threw the wall outward and the roof fell within the building itself before any considerable ignition of its contents had taken place.

So long as the assumed requirements of the retail trade or of any kind of traffic which requires open stocks are assumed to make it necessary to occupy great floor spaces connected by wide and open stairways in very large buildings, it will be useless for owners or occupants to hope to insure their property except at such excessive rates of premium as will cover the maximum of loss from the minimum of cause.

So long as it is considered necessary or expedient to make use of the most combustible kind of material fully prepared for rapid ignition in the finish of a building, owners may as well stop wasting their money in the heavy construction of the walls and the floors. The quicker such buildings fall after they once get well on fire, the safer for the neighboring property.

In the matter of height, taken by itself, without regard to exterior hazard, or to interior finish or to occupancy, underwriters will be obliged to bet that very high buildings may not be injured or destroyed by fire at whatever rates may seem to justify them in taking a wager without any basis of experience to guide them in the matter of prospective losses, if they insure them at all.

It may be mentioned that many years ago the undersigned predicted that the time would come when a great many insurance companies, competing with each other to secure the chance to bet at very low wagers or rates that bad risks would not burn, would end in bankruptcy. The ground was then taken by persons conspicuously engaged in the conduct of insurance companies that such were their functions and that they had nothing whatever to do with the prevention of fire, either in the matter of construction or occupancy of the risks which they insured.

It was then evident that there would sometime be a survival of insurance companies which would be compelled to cope with the hazards of combustible architecture by rendering it unprofitable for owners to indulge in that kind of cheap extravagance at the expense of others. That time has come. The survival of the fittest has made rapid progress in recent years and those which have survived are now exercising a wholesome compulsion upon owners and occupants, both by raising the rates and refusing to insure buildings that are unfit to be built.

In the conduct of this supervision and in the prevention of fire, height is but one element and area is but one element; both of some importance but perhaps neither of paramount importance.

In dealing with the subject in this concise statement I have endeavored to bring into conspicuous notice *all* the important elements which must govern the case. When *all* have been duly considered it is probable that the tendency to build excessively high buildings will be stopped, and that will be one step in saving the huge waste of the fire-tax of this country which now costs—in fire losses, in the cost of sustaining the insurance companies and in the excessive cost of the fire departments combined—*a sum equal to the entire cost*

of sustaining the United States Government in all its parts, together with the interest on the National debt. That cost, omitting pensions, is now about two hundred million dollars a year. The fire-tax of the United States computed by its three elements, comes to approximately the same sum. The Congress of the United States is now occupied in an attempt to exercise economy in the cost of Government. What congress can be summoned that may deal with the fire tax?

There have been several phases in the evolution of building in this country. First and most suitable to its time, and in many respects to all time, is the heavy wooden frame with walls well filled with incombustible material, roofed in an open manner and shingled over mortar.

Second. After the pestilent invention of the buzz-saw, the basket structures were invented which are warranted to burn at a moment's notice.

Third. The composite structures of destructible granite, exposed iron and light wood, held together in the cellular method, each wooden cell connected with the other.

Fourth. The so-called fire-proof construction finished within in many cases in the manner heretofore described; coupled, however, with a few examples of excellent, and in fact, nearly fire-proof construction, well considered and well carried out.

May we not now be about to enter upon the *Age of Clay*, having passed through the several phases of timber, light-wood, iron, granite and steel? One may almost venture to say that we have as yet no science applied to bricks; no science applied to mortar or cement; no true art of construction in brick, fire-clay and tile. We are groping our way to find out how to use our huge abundance of the best materials and to adapt them to the climate and conditions of this country. One can even now conceive of a building of the Moorish tile construction—finished inside with wood pulp rendered incombustible, or with terra-cotta or other form of clay—walled within with plaster board and covered on the outside of the roof with indurated fiber tiles—light, strong and impervious to water. The elements exist even now which when combined, may render it possible to construct a building at low cost which will be sufficiently fire-proof to resist the combustion of its contents. This may be considered a somewhat visionary hypothesis, but such a building is nevertheless within the sight of any one who attempts a forecast in the light of the fires of the past.

THE FUTURE "WORLD'S HIGHWAY."

II. THE NORTH AND SOUTH WATERWAY.

By T. Graham Gribble, C. E.

OUR neighbors in the planet Mars, according to recent astronomical discoveries, are superlative engineers. Water seems to be getting scarce out yonder. The hills are disintegrated and rivers have disappeared. The business of the hydraulic expert includes the manipulation of the ocean, which he trains into canals about fifty miles wide, carrying the discharge of arctic seas, when the summer heat begins to melt the ice, northwards and southwards by main channels, and thence east and west by transverse cuts of similarly colossal dimensions.

Whether or not these recent revelations have been vouchsafed to our juvenile civilization as an inspiration to impel our engineers to undertake a great north and south waterway through the American Continent we do not propose to debate, but one thing is certain, namely, that the Empress River of the New World, the great Mississippi, is operating constantly upon a prodigious scale to bring about a state of things like that which is supposed to obtain in our sister planet.

Every year that great leveller purloins from Uncle Sam ten square miles of his territory, twenty-six feet thick, and deposits these stolen goods in the Gulf of Mexico. In addition it scours along the bottom an amount equal to one square mile, twenty-seven feet thick, and incontinently wastes it along its path wherever fancy moves it, regardless of sidewheelers and propellers. The Mississippi is mobile as a woman's whim and persistent as a woman's purpose. In a single night the great flood of waters will change its course into a new channel, sweeping before it every shred of civilization, sometimes removing whole islands, at others creating them anew. A wondrous girdle of nature truly, but with many a kink and knot in it, appealing to the ingenuity, industry and means of the great race upon which it has devolved as part of the inheritance of their fathers' struggles. The political and commercial value of the Mississippi waterway cannot be fully estimated without considering also the Panama and Nicaragua canals. When the North and South Americas are severed by waterways, the Pacific coast will be

able to send its wine and grain and all its other rich produce at competitive rates to Europe. Captain William L. Merry, President of the San Francisco Chamber of Commerce, writing in the *Forum* of November last, considers that in this interoceanic canal lies the solution of the prosperity of the Pacific coast. He estimates that in the movement of one year's wheat crop five to seven million dollars could be saved in freight, insurance, interest and charges for sacking. Also that fruit could be delivered in Europe by refrigerator steamers in twenty-five days. If in addition to this the transportation can be carried up the Mississippi to St. Louis or Chicago, the value of the waterway becomes enormously increased. The Atlantic seaboard, moreover, is not at present under the control of the United States. Great Britain holds Halifax on the north and the West Indies on the south. She is now making St. Lucia into an impregnable fortress and guarding thus the entrance to the Gulf of Mexico. The Pacific coast is America's own, for it is not likely that Vancouver will ever be developed into a stronghold capable of disturbing the future supremacy of America's naval stations. To possess a means of transporting war-vessels from San Francisco to New York, through American waters without entering the Atlantic, would greatly increase the recuperative force of the nation.*

The problem of how to do it is an immense one. Turning from the canal to the Mississippi the present available depth of that river varies from a minimum of five feet to a maximum of 100 feet. The popular idea is that the lowest depth is the measure of the navigable capacity of the river, but this is not the case. The alternations of high and low water occur with great regularity and the period of high water extending from February to September is utilized by a class of vessels which handle an immense amount of traffic at small cost of transportation and then give place to small-draft vessels during low water. The United States Government, as well as the governments of the several States interested in the development of Mississippi naviga-

* The California Nicaragua Canal Convention held on March 29th at San Francisco, was called for the purpose of stimulating national action toward the completion of the canal. President Warner Miller, of the Canal Construction Company, reported that $700,000 had been spent in 1891; twelve miles of ship-railway completed beyond the first lock, the first mile of the canal seventeen feet deep and 270 feet wide dredged, and the breakwater at Greytown nearly finished. Resolutions were adopted in favor of a national Nicaragua Convention at St. Louis, on June 2 next, St. Louis being the terminal harbor until the way is clear to Chicago. A memorial to Congress was adopted setting forth the importance of the control of this waterway by the United States. The collateral advantage of being able to ship California wines by way of Bordeaux to New York or London was not officially touched upon, but great stress was laid upon the strategic importance of this waterway in obtaining a complete international communication within these vast dominions.

tion, have formulated a general plan of operation which is termed "rectification," and are proceeding with it as fast as the available appropriations permit. The principle is, in a word, to make the river improve itself. To paraphrase the language of the Wise Man, they seek to train the river during low water in the way it should go, so that during high water it may not depart from it. The child is somewhat obstreperous at times, but it has passed through its primary education with honors at the South Pass outlet from New Orleans.

To Captain James Buchanan Eads, genius and man of common sense, the hero of engineering achievements which stand in front rank of modern records, belongs the credit of carrying through the work of self-improvement of the Mississippi mouth. He was not the first to struggle with the mighty waters. As early as 1717 De la Tour made a levee a mile long to protect New Orleans from inundation—a most distinguished feat for those early times. By 1828 levees had become continuous nearly to Red River, a distance of 300 miles. But the main object in view was protection of bottom lands from inundation. Ignorance still prevailed as to the control that man could gain over the great waters. Popular opinion leaned to the view that it was necessary to give the river vent during high water over bottom lands wherewith to expend its energy and, consequently, was opposed to levees. Captain Eads studied the river not from its banks merely but at its bottom. He watched it taking up its load of sediment from the uneven banks and depositing it in the shallows. He examined from a diving-bell the movement of the river bottom, and found it to be a huge shifting mass of sand. He emerged from his life-study to tell his countrymen that the river possessed in itself the power of self-improvement. Instead of dredging its bottom, raking it up with scrapers, or abandoning it to its fate by means of an independent canal at its mouth, all of which schemes were either in operation or proposed by the Government, he not only advocated but contracted to train the river at its mouth so as to obtain a minimum depth of thirty feet. And he did it. Hampered by contending authorities, fettered by doubtful capitalists, Eads never paused, but with iron will drove his ideas through all opposition until his task was done. He possessed the exceptional faculty of teaching people great scientific facts in simple language. He demonstrated the principles upon which sediment was eroded, carried in suspension and finally deposited as being a simple relation between the

THE GREAT LAKES TO THE GULF AND TO THE ATLANTIC.

velocity of the stream and the material of the banks. He showed that not one tiny grain of sand could find its way from a grass-grown bank at Cairo or Baton Rouge to its last resting-place at the bottom of the Gulf of Mexico except in obedience to the well-known law of gravitation. He first studied nature and then the works of other men. He visited Holland with its sluggish streams and the deltas of the great rivers of Europe. Assimilating the best thoughts of others and bringing them to bear upon his own fundamental knowledge he arrived at a plan, simple, cheap, and effectual, something like the dykes of Holland, a series of willow mattresses forming a pair of parallel jetties as a channel for the river. The work of Captain Eads has opened the way to the solution of the whole problem. To replace sharp corners by easy curves and so reduce erosion; to narrow the wide places where the current drops and lets down sediment; to approach as near as possible to conditions of uniform velocity with even banks—such are the chief aims of the improvers of the river now. Knowing the principles it becomes only a question of time and money. A continent destined to be peopled with several hundred million intelligent people will assuredly possess a river capable of transporting vessels of the greatest draft for which the stream is adapted. This may be thirty feet or it may be only twenty feet, but the system will be one of fluvial self-improvement and not an artificial canalization. Rivers, like the better class of domestic servants, understand how to take correction when applied with judgment; the idea that it is necessary to let them have their fling and sow their wild oats over bottom lands has become an exploded notion. A river which is abnormally wide and shallow at any point will not only keep its channel when confined by levees to its normal width but it will do it with great self-satisfaction. The velocity and discharge of a stream are directly proportional, but the scour and power of holding material in suspension vary as the square of the velocity. If a river is narrowed and deepened so as to retain the same area, the velocity and discharge will be greater than before, and the scour and supporting power of suspended material greater still. The scour is prevented from being injurious by the increased smoothness of the artificial banks, and the material instead of being dropped into mudbanks is carried along uniformly. When once the banks have been prevented from erosion, the bottom scour, dependent upon the superincumbent weight of water, adjusts itself to its improved conditions and forms but a small proportion of the previous de-

structive agency of the river. In the Mississippi it has already been shown to be only one-tenth part of the entire erosion.

The following table shows a comparison of conditions between a wide, shallow stream and a narrow, deep one at different longitudinal slopes. The side slopes are supposed to be one tc one. In the first case the depth is 10 feet and the bottom is 100 feet wide, giving a hydraulic mean depth of 8.59 feet. In the second the depth is 20 feet and the bottom is 35 feet wide, giving a hydraulic mean depth of 12.04 feet. The area is in each case the same. The coefficient of roughness is in each case assumed to be 0.25 :

SHALLOW STREAM.				DEEP STREAM SLOPES AS BEFORE.			
Slope in feet per mile.	Theoretical head in feet.	Velocity in feet per sec.	Velocity in miles per hour.	Velocity in feet per sec.	Velocity in miles per hour.	Increase of velocity and discharge.	Increase of scour and supporting power.
						Per cent	Per cent.
.132	.031	1.42	0.96	1.87	1.27	31.5	74.5
.264	.0565	1.91	1.30	2.46	1.68	29.0	66.0
.528	.1055	2.61	1.78	3.30	2.24	26.5	59.5
1.056	.196	3.56	2.42	4.47	3.20	25.5	56.7
2.640	.48	5 56	3.78	6.90	4.70	26.5	54.5
52.800	9.40	24.60	16.71	33.50	22.8	37.0	85.2

It has already been remarked in the first article that canals with locks have always labored under the disadvantage of their incapacity to follow the development of shipbuilding. The natural outlet from Lake Michigan to the Gulf is by means of the Illinois river and waterway, the improvement of which has hitherto been conducted by means of dams and canals without regard to its place in the greater project of the future. In the conflict of expert opinion which is going on we have a repetition of that which kept back for some time the improvement of the Mississippi mouth.

The Government engineers who have been instrumental in constructing the dam at La Grange on the Illinois river are also engaged in constructing another dam at Kampsville. The State has also constructed dams at Henry and Copperas creek. Local opinion is adverse to them. Land-owners complain that the bottom lands are saturated, that tributary streams silt up and overflows result during the tilling season, but the authorities do not like to change their program. On the other hand they propose just as they did at the mouth of the river, an independent canal with locks from Henne-

pin on the Illinois to Rock Island on the upper Mississippi. This canal is to have no less than thirty-seven locks, and it makes a connection with the Mississippi so far above its confluence with the Missouri that not only does it form a roundabout way of getting from point to point, but it also joins what is in fact the tributary instead of joining the main river. The opinion of the board of engineers who pronounced in favor of the Hennepin canal has been ratified by Congress, but the subject has been recently so much ventilated by public expression of contrary views that it is to be hoped no great outlay of public money will be devoted to a scheme which is as yet certainly not endorsed by the best civil engineers nor by present general public opinion in the State of Illinois.

The scheme for using the Illinois river by improving that waterway to such an extent as to make it a fit arterial connection with the Mississippi river has been for a long time before the public, and is supported by very strong engineering authority. In addition to widening and deepening the present channel, it is proposed to introduce a flow of water from Lake Michigan to supplement the natural discharge of the river. It is also proposed to utilize the new channel for the discharge of Chicago sewage.

It would certainly appear to be the most natural solution of the present drainage problem in Chicago and to meet the necessities of increased population for some time to come. It has been argued by the Government authorities that there was here an attempt on the part of the city of Chicago to obtain public funds for private necessities, but Chicago meets this charge by offering to pay her share. The metropolis of the West is situated in circumstances of difficulty for disposing of sewage in any other way than by water-carriage. Other cities have the same difficulty but it is the magnitude of the problem both now and in the future which creates the dilemma in Chicago as it has done in London.

The natural manner of sewage disposal is the dry-earth system. Our friend, the cat, unlike some other domestic animals, is endowed by nature with certain instincts from which sanitary engineers borrow hints even to-day. She appears to be acquainted not only with the need of concealing but also of disposing to advantage those affairs which are apt to bring her into collision with the housekeeper. A convenient hole in the garden becomes the cloaca of the cat and the fertilizer of surrounding vegetation. Small towns with one or two-story houses often adopt with considerable success the feline process. In large cities, however, the latrines supply only a small portion of

the stream of pollution; chemical works, abattoirs and a host of other necessary defilers of pure water demand continual copious streams to dilute and remove their refuse. The question of sewage disposal has perhaps been more debated in London than anywhere else. The late Sir Joseph Bazalgette, who first became famous by his main drainage scheme and then by the Thames embankment, was always a staunch advocate of water carriage. A year or two before his death he was compelled by the Board of Works to design and carry out works for precipitation of the solid matters at the outfall and the removal of them by specially designed steam barges to the ocean. He was, however, always in favor of continuing the main channels to the sea. He regarded the precipitation as a temporary expedient and held the initial expense of the continuous culvert vast as it was to be the cheaper method in the end. Chicago cannot put sewage into the lake. To make a farm out of bottom lands and filtrate would occupy a very large area because the soil is clay. Precipitation is very costly if done properly, since the works have to be constructed upon a scale capable of handling all the storm waters which flush the sewers, otherwise the effluent becomes at such times nothing better than ordinary sewage. This is rarely done and consequently during storms the precipitation process breaks down altogether. It has been satisfactorily proved that with a sufficient quantity of pure water to flush it, the light flocculent matters of ordinary sewage rapidly oxidize and part with their offensive properties. It must on the other hand be admitted that deleterious germs are carried by water over vast distances, but they also will pass intact through almost any filtering medium, such as the spongy iron used at the Antwerp waterworks. Even though the sewage were disposed of by irrigation, the effluent would finally find its way into a waterway and would be as liable to carry certain germs as if it had not been filtered. The reports of Messrs. Rudolph Hering, Benezette Williams and W. E. Worthen upon the sewage question for Chicago and the exhaustive report of Mr. L. E. Cooley upon the proposed waterway contain a record of the great study and research which have been brought to bear upon this problem and the report of Captain Marshall, United States Corps of Engineers, represents on the other side those views which for the present appear to have had the most weight at Washington, namely, a shallow channel with preservation of present dams along the Illinois river and an independent canal from Hennepin to Rock Island.

The Chicago Waterway Laws of 1889 provide for the abstraction of a volume of water from Lake Michigan equal to 5000 cubic feet per second, and as soon as the channel shall be rendered capable of receiving it the volume to be doubled. The discharge over the two falls at Niagara is estimated at 400,000 cubic feet per second, and to have a depth of twenty feet at the crest. The final demand of the Chicago waterway is therefore one-fortieth of the total volume and it would reduce the depth over the crest of the falls by about six inches.

The volume of 10,000 cubic feet per second is provided for by the Chicago laws on the basis of 20,000 cubic feet per minute being required for every 100,000 inhabitants, or in other words 10,000 cubic feet per second will suffice for 3,000,000 persons, a population which at present rates of increase will probably be reached by Chicago about the year 1910. The larger volume is furthermore to be provided for wherever there are rock cuts, the depth being eighteen feet and the bottom width 160 feet.

The various Government estimates of cost for an eight foot and a fourteen-foot waterway have been analyzed by Mr. L. E. Cooley, formerly engineer to the Board of Trustees for the Sanitary District of Chicago, but now a member of that Board and chairman of the engineering committee. The estimates only go as far as Utica. The estimate of Captain Marshall for an eight-foot waterway from Chicago to Lake Joliet, a distance of forty-one miles is $18,699,789, and for a fourteen-foot waterway $24,884,618. These sums each include the same allowance for 11,500 lineal feet of docking in Chicago, and twenty-three bridges. The estimate of the same authority for an eight-foot waterway from Lake Joliet to Utica, a distance of sixty-one miles is $8,183,364 and for a fourteen-foot waterway $23,398,145. Mr. Cooley makes numerous criticisms upon Captain Marshall's figures, all tending to prove the estimates excessive. He contrasts other estimates by different authorities, and also disputes many of Captain Marshall's conclusions. His opinions are strongly urged and carry the weight of large experience. There are as yet, however, no other data available from which to arrive at an estimate of the total cost to the nation of the completed waterway from the Lakes to the Gulf. It will be seen that we have in the distance to Utica less than a third of the whole distance to the Mississippi, but beyond Utica, the lower Illinois is an alluvial stream requiring no expensive work as in the rock of the Chicago Divide. Mr. Cooley argues that a progressive system of improve-

ment by dredging and levees can be carried out at less cost than the dams proposed by the Government engineers, and not only without injury to bottom lands but having as its ultimate achievement the complete reclamation of the said lands, the value of which to the State he estimates at thirty million dollars.

Mr. Cooley estimates that the work required to reach Lake Joliet, forty-one miles, is almost exactly the same as that done on the Manchester Ship Canal and will not exceed $30,000,000. The work required to continue the channel with a depth of fourteen feet, 320 miles, to St. Louis, will not exceed this amount, so the Chicago Divide is the "Gordian knot" of the whole question of deep water from the Lakes to the Mississippi.

The sewage of Chicago goes to-day in theory to New Orleans but in practice it stays at home. As the guide-book hath it: "The drainage of this great city was a serious and perplexing problem until by a triumph of engineering skill the current of the Chicago river was reversed, and the stream made to run *out of* Lake Michigan into the Illinois and Michigan Canal, and thence through the Illinois river to the Mississippi." The German philosopher says: "Eigenes dreck stinkt nicht," but even the patriots of Chicago cannot deny the presence of something more than the dews of heaven and dissolved snowflakes in the city's waterway.

It may justly be argued that the disposal of Chicago sewage should not be made an essential factor in a scheme of national importance such as the great north and south waterway, but on the other hand the cost of the waterway, as far as concerns the outlet for the city sewage, is to be defrayed by the city, and it is therefore claimed by the latter that a fourteen-foot and eventually a much greater depth is thus secured to the waterway instead of a shallow one as advocated by the United States Engineers.

It is possible that with the growth of Chicago to the enormous proportions which are prophesied for her, the sewage question will crop up again even after it has been told to consider itself drowned for evermore. It may then be more difficult to make drafts upon Niagara than it is now, and the city may have to look out for some bottom lands to raise "Chicago cabbages" on. The Lake and Gulf waterway will have to thank Chicago sewage for giving it a first start and, having established a new and growing business, it will be able to provide for its own development.

In our third and last article of this series, we will consider the subject of the waterway from the Lakes eastward to the Ocean.

THE BEGINNINGS OF ARCHITECTURE.

By Hyland C. Kirk.

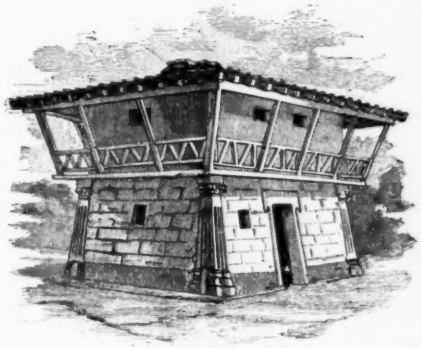
THE idea of personal protection and defense was the first consideration which guided man in the selection or construction of a dwelling-place. Not even ease and comfort, as we understand these terms, seem to have had a place in the minds of primeval builders. This strictly utilitarian motive does not lack examples even now, enabling us to study side by side with the highest triumphs of architectural skill, the earliest crude conceptions of house-making. Regardless of the rest of the world the Bedouin still protects himself from the sun and desert heat with a faded, dingy tent woven of camel's or goat's hair; the Australian continues to rear his bush lodge to break the chilling winds, and the Eskimo of to-day builds his igloo of snow on the plans of the first builder of his race.

Visitors to the late Paris Exhibition will recall the series of models illustrating the dwellings of all nations, which were arranged on the Quai d'Orsay, designed by M. Charles Garnier, architect of the Opera-House, with the assistance of Professor Ammann. Here were shown, first, prehistoric constructions—cave-dwellings, lake-dwellings erected on piles, stone huts, earthen huts and bower-houses made of branches and leaves. The caves of primeval man, the bark wigwams of the reindeer epoch, the dwellings of the stone age constructed of huge cavernous monoliths and roofed with trees, the lake-dwellings of the age of bronze, and the adobe houses of the age of iron, were all exhibited. This series was to many visitors one of the most interesting features of the Exhibition. It is referred to here both as pertinent to the present paper and as a reminder of what we may expect, perhaps, in this line at Chicago. These models were occupied by people dressed in appropriate national costumes and working at some trade or occupation peculiar to each country whose architecture was illustrated. The pristine habitations of rock and mud were left untenanted, because of the uncertainty relating to the costumes and building implements of prehistoric times. Aside from the omissions in certain types, as the heavy columns of the Egyptian style, the peculiar system of domes resting upon arches in the Byzantine and some others, the

chief thing wanting in these exhibits was that we could not see the primitive workman in the construction of his edifice or feel with him the motives which urged on his labor.

Historically the work of some of the first builders of human habitations is believed to be traceable in the dredgings of the lakes in Switzerland, where a race of dwarfs built their dwellings on piles as a means of protection from noxious beasts and for the additional purpose of catching fish. This method of protection through the location of supra-aquatic dwellings was extensively adopted by primitive man. The submerged remains of such dwellings have been discovered in the lakes of Sweden, Ireland and Italy. The Papoos of New Guinea, the Borneans and also fishermen on the Volga still practice the same thing. Ojeda and Vespucci found an Indian village constructed on piles in Lake Maracaybo and so called the country Venezuela—Little Venice. Dwellings of this character are still found in the Orinoco. The city of ancient Mexico was founded in this way, and built almost entirely upon the lake. It would be interesting to consider this one phase of the subject and to trace in this species of architecture, beginning with the fisher-hut of the Swiss lakes, the culmination of the plan on the islands of a lagoon in the Adriatic, where the inhabitants of Padua, Verona and other cities, fleeing from Attila, took

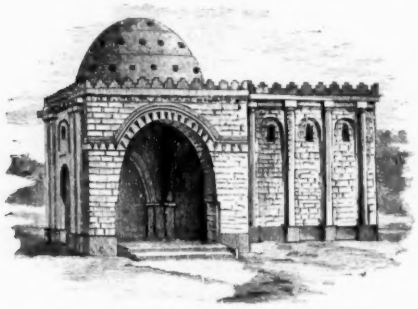
PRIMITIVE LAKE DWELLING.



ANCIENT ETRUSCAN HOUSE.

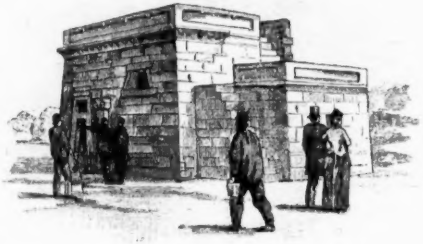
refuge, whence arose that magnificent series of architectural triumphs to be found in Venice, the "Queen City of the Sea."

Continuing the investigation of the defensive character of the beginnings of all architecture, the Etruscan house, with its loop-hole windows and balcony running around the upper story, the whole suggestive of a fort, affords another illustration. So the lofty battlements of the Persian house, and the tower-like structure of the Hindoo dwelling, both suggest the idea of defense in the original pattern. The solid masonry of the Hebrew house suggests the time when the contests with Canaanites and the Philistines caused them to abandon tents and build strong houses. These inferences are the more readily conceivable as war was the original state of man.

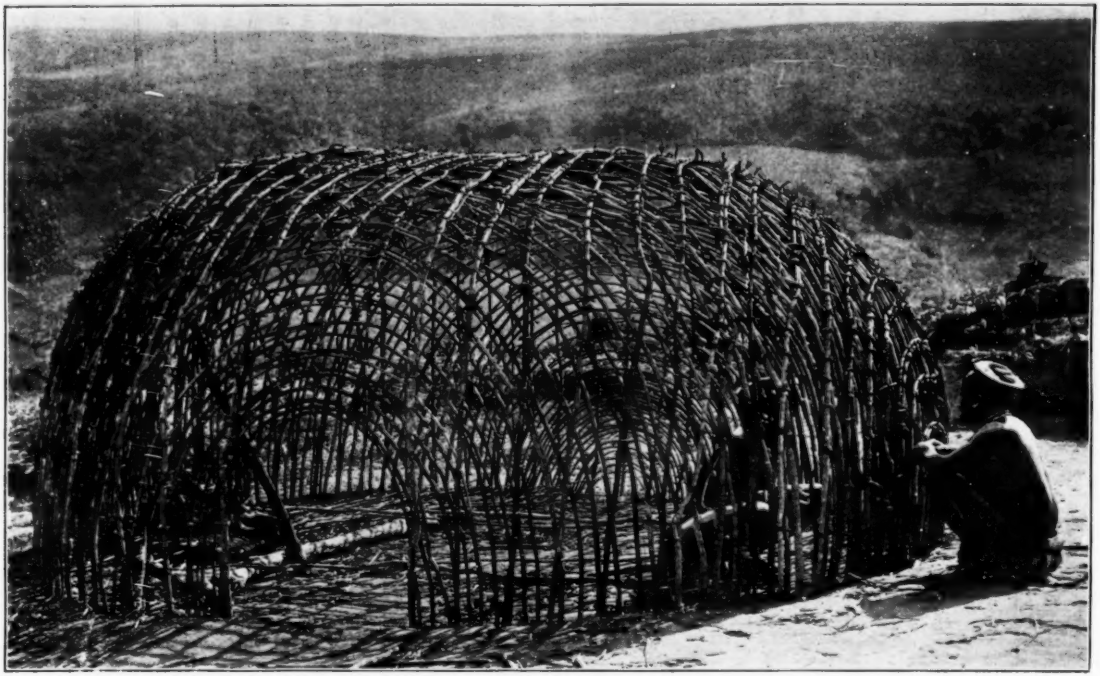


ANCIENT PERSIAN DWELLING.

How the temporary shelter became a hut, the hut a gabled house, and the house a many storied palace; how from the cavern excavated by some convulsion of nature, the castle came to be constructed, we leave to the historical student of this art. He may find that the Egyptian column represented but a stalk of the lotus with its calyx for a capital, and so discover a peculiar significance in the distinguishing characteristics of every style and form of architecture with its historical origin. In this paper these primitive forms will be considered merely as the reduplication of the earliest dwellings by the still savage descendants of primeval man—dwellings to be found in the wilds of Africa, Asia and of America; the



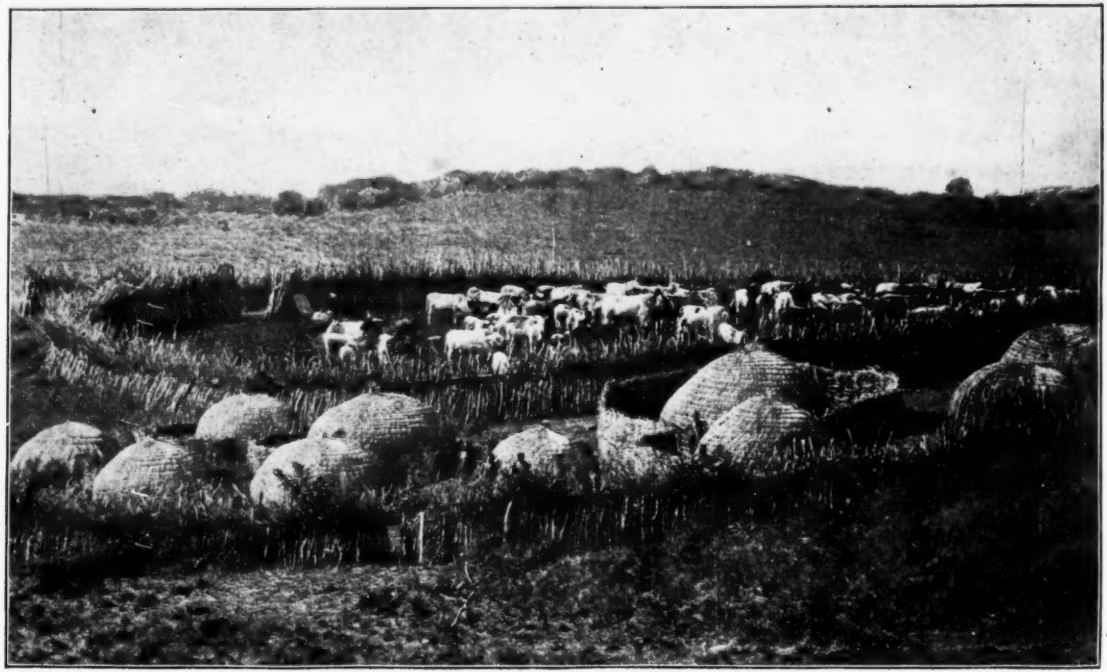
ANCIENT HEBREW DWELLING.



BUILDING A KAFFIR HUT, SHOWING PRIMITIVE FORM OF THE ARCH.

abodes of the Kaffirs, Kalmucks, Eskimos, Sioux and Caribs. When it has once been decided that a Kaffir house should be built, a decision of course arrived at by the august being who, with the exception of caring for his cattle, does no work of any kind, and who presides over the immediate destinies of the women of his household, no time is wasted on preliminary surveys. The kraal and its attendant cattle-pens and human habitations are located usually on a descending slope or mountain side, that the approach of enemies may be the better observed and attacks resisted. Any open space from twelve to thirty feet in diameter will do. Often the size is left to be determined by the materials used. Sometimes, however, a circle or oval is roughly drawn on the ground, and the foundation of the building is ready. The woman architect next proceeds to tie together *in extenso* a number of flexible poles. One of these spliced rods she thrusts deep into the earth at the foundation line on one side, and, bending it over, sinks the other end on the opposite side of the domestic site, thus forming an arch.

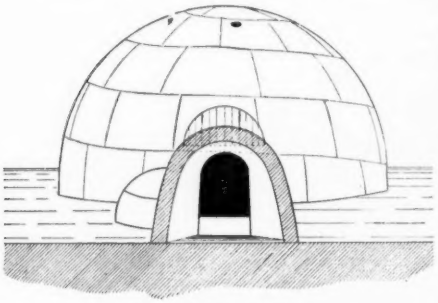
The Rev. John W. Chadwick, in his recent essay on "The Evolution of Architecture," says: "Building is not architecture till it makes for beauty, not for use alone. Could there have been preserved to us any of the caves, or huts, or tents, of the primeval races, we should doubtless know that this 'making for beauty' was at an early stage." The palm-leaf tent, the bush hut and the natural cave of to-day would appear to possess in themselves as much evidence of their primitive character for the purpose of human habitation as there seems to be of primitive simplicity in the reverend gentleman's statement; though in favorable contrast to other critics he concedes to utility an important part in the origin of architecture. Certain nomad Arabs yet use natural caverns for dwellings, as do the eastern Tasmanians, fishermen of the Congo, and some of the Sandwich Islanders. Nature affords lines of grace and "makes for beauty" as well as art; and the dwellings of the primeval Troglodytes could not have been more primitive in character than we find existing among Australians and Digger Indians. The arch, however crude, is always a thing of beauty. That it belongs to masonry as a practical branch of architecture must be admitted, but the idea as involved in the primitive form antedates all masonry. This simple structure of pliant wood, the first element of the Kaffir hut, stands as the primitive type of the Roman arch with its columns attached to the front; the Lombardian arch mounted upon its columns; the Byzantine surmounted



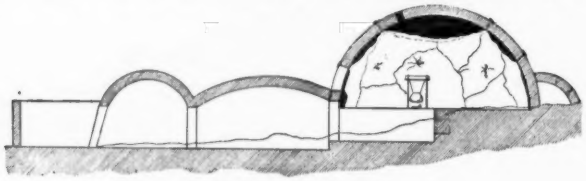
KAFFIR KRAAL IN THE TRANSVAAL, NEAR MURCHINSON RANGE.

with systems of domes, the bulbous Arabian with a flat roof above, the receding Norman supported by pillars, and finally the noble Gothic with its pointed apex surmounted by a gabled roof having sharp angles.

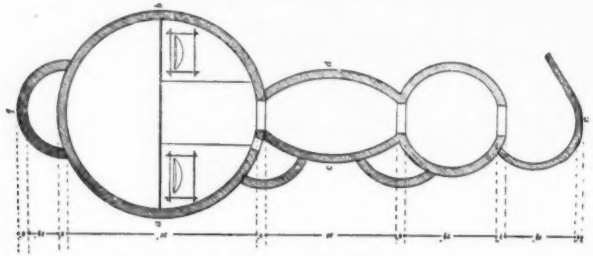
The unclad Kaffir woman, however, works away unawed by the significance of her art. If the house is to be circular another spliced rod is arched similarly at right angles to the first and the two are tied together firmly where they meet. These rods are multiplied until the vertical portion of the skeleton is completed. The next step consists in intertwining laterally any lithe material for battening. Usually "monkey-rope," a species of creeper found in abundance in the forests, is used for this purpose. If the house is to be oblate in form, the preliminary arches are not placed in parallel rows but three arches are used at the beginning of the



ESKIMO IGLOO—FRONT.



ESKIMO IGLOO—SECTION.



ESKIMO IGLOO—PLAN.

KAFFIR HUT SHOWING TEXTURE OF THATCH—BERSUTU WOMEN, PRIMITIVE ARCH-BUILDERS.

NATIVE KAFFIR HUT—NATAL.

work, one fixed across the middle of the oval space, and two longer ones crossing this extend nearly to the ends of the proposed habitation. An inspection of an accompanying engraving from a photograph taken in the Transvaal will give a good idea of this preliminary structure. The next step is thatching the framework with bundles of heath grass, which are laid on in sections of overlapping layers and bound with strips of untanned leather or monkey-rope. The crude manner in which this thatch is applied is noticeable in another view shown, taken near the Limpopo river. The two Bersutu women are types of the Kaffirs found in that region.

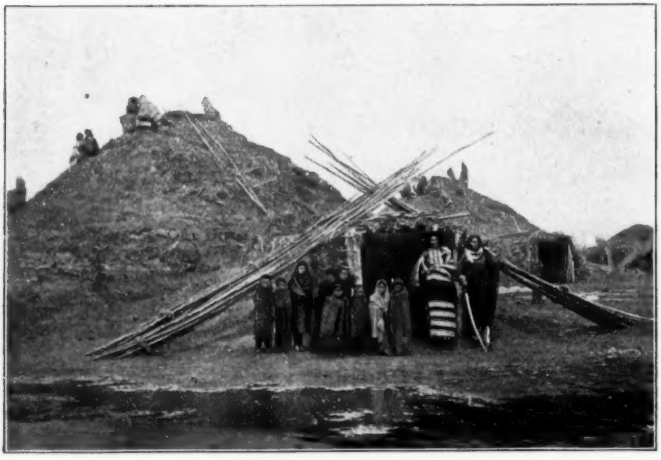
That the Kaffir dwelling should be very similar in pattern and in mode of construction to huts mentioned in the early history of other parts of the world is somewhat remarkable, from the fact that the Kaffir is not, like the Hottentot, nomadic in his habits, but prefers to remain settled in one place. The hut is fixed in the ground for a permanent abode ; a cement flooring, frequently made from the nests of the white-ant, is laid, a wicker door put in, and the women line it with mats made of heath or fronds firmly secured to the sides.

The Bushman's house is frequently a bush in which he makes a nest ; whence his name. Could Mr. Chadwick ask for a more primitive dwelling than this? A more elaborate Hottentot house is patterned after that of the Kaffir and differs from it merely

MODERN PUEBLO, ZUNI INDIANS— NEW MEXICO, UNITED STATES.

in the fact that it is made in removable sections, the mats lining the interior being hung up, so they may be taken down and packed in a few minutes. The early Britons and Gauls who slept in fields and caves could boast of no better dwellings than the Bushman's temporary shelter. The east-coast Kaffirs build a quadrangular hut of better structure than those described. Besides the four corner posts supporting the plaited walls, there is a center-pole supporting the peak of the roof, a door which swings on untanned-leather hinges, and other points of superiority. The three principal classes of African dwellings are those described, such as the Kaffirs and Hottentots build; the circular stockade hut with perpendicular sides and conical thatch, such as are found among the Bechuanas, and the "tembe" of certain central and eastern African tribes, which bear the impress in some degree of Oriental civilization, being made of a series of huts facing inward or one habitation possessing a form of interior court.

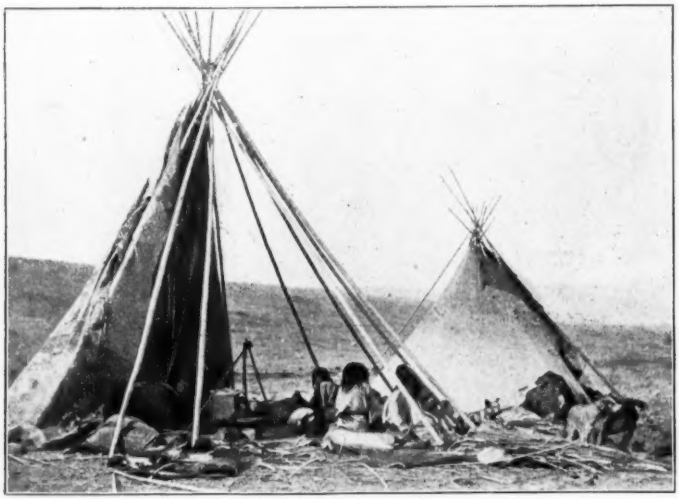
The dwellings of the Asiatics, barbarians though they may be considered, are many of them too well-constructed and too elaborate to be considered in connection with the beginnings of architecture. But the Todas, the Bhils of the Vindhya mountains, and some other hill tribes of India, live in oval-shaped huts built of bamboo, fastened with rattan and covered with thatch. These are well-constructed, but without chimney or window, and are perhaps



PAWNEE LODGES—UNITED STATES.

NAVAJO HOGAN—NEW MEXICO, UNITED STATES.

the simplest type of dwelling to be found among Asiatic races, if we exclude the bush-dwellers of Further India. The bamboo appears to bear the relation to the developed architecture of the Hindoos, their gorgeous palaces and temples, that the lotus bears to the Egyptian, or the acanthus to the Corinthian type. Edwin Arnold says: "The palace at Ulwar is a good example of modern Hindoo architecture of the ornamental and latter-day kind. There is a rich, ornamental frontal wall with little cupolas over the gates as well as upon each corner, the exquisite shape of which is directly borrowed from the curves assumed by the bamboo when it is bent to form a roof."



CROW LODGES—UNITED STATES.

The Gonds of the plains along the Hindus build houses of "wattle and daub" and thatch them with teak leaves and grass. The Karens of Burmah and Siam erect their bamboo houses eight or ten feet above the ground as a matter of safety. The Kirghiz of Central Asia live in bee-hive tents with a frame-work of willow. The Kalmucks, roving Gypsies of the Obi, who move every three or four days, have circular movable tents with willow frame-works, covered with felt. Other northern Asiatic nomads use similar habitations in summer, but in winter live in yurts—dwellings more resembling the Eskimo igloo.

The "family wuurn" of western Victoria, Australia, according to Dawson, is usually made of strong limbs stuck up in dome-shape and covered with bark, thatch, sods or earth. A building of flat stones is sometimes made and roofed with branches and thatch. Tahitians, New Zealanders and Sumatrans build oblong dwellings of poles or bamboo, as do the better class of the Malagasy. Provincial Malagasy frequently live in mere excavations covered with grass. On the eastern continent, Polynesia and North America, the circular form of savage dwelling seems to prevail, while among the South American natives of to-day rectangular forms are more prevalent. The Arawaks of Guiana build square huts of palm, using the leaves for thatch. The Tupis, who change their dwellings as soon as the thatch of the roof decays, the Guaranis, and Cooados, all of the Amazon, build quadrangular houses of wood and thatch them with palm-leaves, while the Mundrucus build conical huts generally of "wattle and daub" similar to the ancient Quichua habitations shown in one of the illustrations in this paper.

The "wild" North American Indian of to-day differs from the aboriginal savage of this continent somewhat, and his "lodge" differs accordingly. With the exception of the quadrangular bark-house of the Iroquois, the Indian dwelling in most instances was formerly covered with the skins of animals killed in the chase; it is now more frequently covered with cotton cloth. The Snakes, Comanches, Chippewas and Dakotas formerly made their lodges of poles conical in form and covered them with bark or skins leaving an opening at the top for the escape of the smoke. The "teepes" of the plains Indians—those between the Mississippi and the Rocky mountains—according to Colonel R. I. Dodge, are very similar to these in appearance and character.

The Indian "wicky-up," is a temporary or summer lodge. It is made of poles stuck in the ground and bent over to form a support which is covered with skins or blankets. The Omaha Indians build a quadrangular lodge with forked poles for posts and cross-pieces; while the Osages make a lodge with slender bows, similar in shape to the top of an emigrant wagon. The summer lodges of the Indians of northern latitudes in most cases are different from their winter residences. Eskimos in summer dwell in skin tents but retire in winter to the igloos made of wood or whale-bone and covered with turf and snow. These are often sunk in the ground and entered by winding tunnels. The shacks or permanent dwellings of the Chinooks are usually sunk in the ground. The Mandans of the

Upper Missouri build permanent circular huts from forty to sixty feet in diameter with the floor sunk several feet below the surface. In these the earth is made use of to secure warmth. The Pueblos of Arizona obtain quite the opposite result from the use of earthen dwellings. Various writers have pointed out that their commune houses, typifying as they frequently do the cavern and the fortress, were so constructed originally for defense; but the plan obtains now more because of the lower temperature they afford.

Though some would trace the classic in this art to the erection of crude temples; and others going further back would find in the apotheosis of dead heroes the starting point and thus evolve the palace from the tomb; yet the necessity for protective coverings and military defenses with primitive man as with the savage of to-day would seem to have impelled its real beginning. In "necessity, the mother of invention," we may follow out in every direction the multiform handicraft of man. No less in architecture does this principle prevail. By means of it largely, at every stage, the designer drew his plans and the workman plied his craft; and its influence may be traced from nature's shade and the natural fortress, from the cavern's warmth and fisher-hut, to the spacious structures of commerce, the gorgeous palace and magnificent cathedral.

ANCIENT QUICHUA INDIAN HUT—BOLIVIA.

THE DISSOLVING POLITICAL REGIME.

By William Nelson Black.

SHOULD government be the object or only the incident of social administration? "Why, the incident, of course," comes back in universal chorus. Whether a man be Czar, Kaiser, King, or President, he will not willingly admit that his rule is maintained for his own personal emolument, and the emolument of his political supporters, distinguished from the masses either by caste or official affiliation. If put to the test, most men will be willing to concede that the object of government is well enough defined in the Jeffersonian formula which limits it to the protection of life and property. A few will be found who will talk of its usefulness as the promoter of art and learning; but they will not be men well instructed in history or they would know that both art and learning have received their best encouragement in independence of government. A few, also, will talk of its utility in the construction of public works; but when it is seen that after some thousands of years of government, devoted mainly to war and conquest, the world contains only a very limited number of important public works constructed by government, these few will be silenced if they are sensible.

Nevertheless, it can hardly be questioned that government is everywhere administered as though it were the main object of all our social activity. The daily and nightly study of the crowned head is given to the consideration of the best measures for perpetuating the kingly regime. The President lies awake at night planning measures for compassing his re-election or the success of his party; and all legislative measures conceived with a political object in view take precedence over measures with no political significance. Everywhere we find public officials conducting themselves as though they thought government the chief end of man.

Well, doubtless it is the chief end of the men who live by it; and as history has been chiefly concerned with the exploits of heroes, and as most men are easily dazzled by the dramatic incidents of warfare, it has come to pass that the functions of government have become unduly exalted in even the popular conception. But when we look around and see the number of men who are de-

pendent on government for subsistence, and compare it with the number who pay taxes for their support, we are compelled to wonder at the consideration given to a form of social organization which the evolution of modern society is proving to be as unnecessary as it is wasteful and oppressive. There are perhaps five or six thousand men all told who live by the strictly political functions of government in the city of New York, and there are certainly little more than twice that number in the entire State. But there are several millions who train at the heels of these few thousand, and never stop to inquire whether or not, in the first place, most of the service rendered is worth while, and whether or not, in the second place, the little that is worth while could not be more cheaply and efficiently rendered if made an incident in economic administration, and turned over to the control of economic agencies. Really the world needs very little government that is not supplied by the courts acting on those judicial principles that receive their best exposition in the common law. Supplemented by the police, the courts give us the best part of the protection required ; and ninety-nine one-hundredths of this great body of regulations which we call statutes is simply a product of the meddlesome traits of human nature finding expression through men who have only political objects in view.

But the world is gaining wisdom from its thinkers. A much misapprehended force has been at work in society recently, and great as have been its exploits it has reached only the threshold of its conquests. This is economic organization. Proudhon, Herbert Spencer, and even a man so prominently and illustriously identified with political organization as Abraham Lincoln, have comprehended the new force, a force which has reached the present stages of its development during the last three hundred years. A man must be dull or blind indeed who has read the history of these three centuries and observed the achievements of co-operative combinations in works of engineering construction, commerce, and general industry, if he fails to see that political organization is a tradition, and that the period of its dissolution will be coincident with the time when the economic giant will have become fully developed, and all men have learned to avail themselves of its resources. It was during the reign of Queen Elizabeth when the East India Company, practically about the first corporate organization ever formed, was chartered. But, without firing a shot, it only took a few years for this company to drive the Portuguese Govern-

ment, then a powerful political force in Europe struggling for the conquest of India, out of the country; and it finally won the territory, with its 250,000,000 inhabitants, to the British Crown. Alexander the Great only came to the borders of that vast congregation of humanity before whom the Portuguese were compelled to flee ignominiously, and the hitherto invincible conqueror retired baffled. But a handful of traders, provided with a few cargoes of English gimcracks, came, and the wealth of Indus was unlocked for their emolument. It is a pity that the company did not know how to make a better use of its conquest, the most wonderful in history. It only turned it over to a force, which it had already discredited, and, as the sequel will prove, wounded to the death. But the giant was then as now trailing its plumes in the wake of a superstition, and knew little of its own resources.

Political organization is rudimentary. It was born in the childhood of the race, and it can never serve society after the end of its period of adolescence. As men emerge from barbarism, and begin to find the utility of their industrial faculties, they advance through the various stages of tribal, monarchical, and republican organization, or government, so called, each step marking a distinct advance in the evolution of civilization; but the goal toward which all their activities tend will never be reached until the shackles of this rudimentary organization have been removed, and they have learned to find in the machinery of their industries all the regulating forces that society needs. To-day, in its desperate struggle for life, political organization is playing a comedy, and giving a spectacle which would be infinitely amusing were it not so full of tragic incidents and situations. Its armies in line of battle would reach across a continent; its battle-ships are more than enough to fill a sea; and its fiscal obligations, contracted to meet the expense of maintaining its gentlemanly stage-walkers and chief players, are piled higher than the Alps. But what does it all signify? Give to economic agencies all the needed functions exercised by political organization and the public administration would be conducted more cheaply, more efficiently, more honestly, and with greater regard for the peace and welfare of society than it has ever been in the past.

Will any reader have difficulty in comprehending how this would be possible? Study the subject by illustrations, then, and find the first example in one department of political organization. Take its police department. The political police system is concededly very inefficient. Aided by the military sometimes, and sometimes alone, it

may be equal to the suppression of riots in our large centers of population ; but for the general protection of the community it is notoriously inefficient. Go about the streets at night in our chief city, New York, and be observant. But do not make the blunder of supposing that every man seen in uniform and carrying a club is a municipal policeman. He may be a municipal policeman or he may be the member of some private organization that finds it profitable to employ him to supplement the work of the political force ostensibly giving protection, but not trusted. New York pays several millions a year to maintain its political police ; but the private citizens of New York are compelled to add a possibly still greater number of millions to secure the protection which the police fail to give. Is it business-like to pay and continue paying for a service which is not rendered?

Now let us suppose that in place of these ornamental gentlemen with a pull, many of whom are doubtless good officers and would do better service if surrounded by less arbitrary influences, the Pinkerton Detective Agency, or some similar organization, were placed in charge of the entire city under a contract to preserve the peace, furnish night watchmen, and see that all needed regulations were enforced. Can it be doubted that a greatly improved service would be found, and that it would be obtained at a great reduction in the total cost ? Only a comparatively small regular force composed mainly of detectives and night watchmen would be required. The political police is maintained in heavy force largely for emergencies ; but under an economic system thousands of men could be cheaply enrolled in an auxiliary force to serve only on occasions of unusual demand. It would be, therefore, a flexible service always just equal to the occasion. In either country or town an economic police system would be more far reaching, more available, and more generally serviceable than the political system. Its general superiority has already been demonstrated, indeed, for it has grown into being in spite of the political system, and the sooner we make it exclusive the better. Men who are calling the Pinkerton detectives thugs and demanding that their usefulness shall be impaired are only asking that the military methods of political organization shall be perpetuated against less offensive methods.

This is one illustration and there is plenty more material. Municipal, State, and Federal operations combined give us an embarrassment of illustrative riches ; but where it is so abundant that

it is seen everywhere it is difficult to make a choice. In the place of attempting to make a selection, then, perhaps it would be best to inquire not where economic organization would be better than political organization in the administration of public affairs, but where it would not be better. This will so contract the field that it can be soon surveyed. Certain desirable operations are supposed to be inevitably non-productive, and therefore beyond the reach of economic agencies. Here would be postulated the first argument for the defense of political processes; and legislative bodies and the courts will also suggest themselves as something to be maintained. We must have some general regulations for human conduct, and we must have justice.

With regard to the necessarily non-productive operations carried forward through political organization, they are so few in this country that it is hard to find a single example. The new line of inquiry has so contracted the field that it is almost invisible. But, stay! The sound of log-rolling, re-echoed through the West and South, comes up from Washington, and the river-and-harbor bill is suggested. How would we obtain our biennial appropriation for the improvement of rivers and harbors if we cut loose from taxation and made every operation pay its own way?

Well, perhaps the change would not promote the enlargement of the Chesequake creeks of the river-and-harbor bill. But this would be no loss to the public; and as to the harbors of our large commercial cities they could very well be made to pay their way, and yet be more comprehensively improved than they have ever been by the processes of log-rolling and taxation. It would not require a very oppressive levy on commerce to keep improvements constantly under way in the harbor of any port with a traffic worth considering.

The readers of THE ENGINEERING MAGAZINE have been treated to some expert opinions recently on the efficiency of the Government service in the improvement of rivers and harbors, and they know that a great deal can be said that is not flattering. The gentlemen in charge unquestionably know a great deal about bastions, embrasures and esplanades. They could distinguish a glacis from a toboggan chute. They would know, too, how to undermine a town and blow out its foundations. But they have been taught to work without any consideration of cost or economy, and are probably among the last men in the world who would be likely to have a quick perception of the needs of commerce and navigation.

Our harbors would be better improved were the work done by private companies and the cost levied directly upon commerce Mr. George Y. Wisner told us in the March number of this magazine that the Manasquan river was so efficiently improved at the harbor entrance by Government engineers that a new appropriation has been voted by Congress to remove the obstructing improvement! This recalls the testimony which accused the New York dock department before an investigating committee of dredging on one side of a pier and dumping the earth on the other side in order to enlarge the dredging contract. It is safe to say that no such performances would be reported were all our harbor improvements in the hands of men intent only on earning money legitimately. A few words may be profitably said here, too, in relation to some of our river improvements. Under the stimulus of munificent Congressional appropriations there is too much reason to fear that, like the Yellow river in China and the Po in Italy, the Mississippi river, continually depositing sediment on its bottom, is being lifted by levees year by year to the summit of a continually rising ridge. What dangers, perplexities, and catastrophes may we not be providing for posterity by this sort of improvement when this country becomes as thickly populated as China! Would not the opening of new channels through the connected bayous of Louisiana for the purpose of lowering the bed of the river instead of raising it be a more sensible improvement? We may be sure that it is the kind of improvement that the citizens of the threatened district would first essay were they dependent on their own resources. As to those corollaries of the river-and-harbor bill, the canal schemes, of which the Hennepin canal scheme is alone chronic, it is too late in the day to even mention them except for condemnation. Were the Hennepin canal needed its construction could be made profitable, and it would have been finished before now by a corporation.

The river-and-harbor bill cannot be made a defense for political methods, and we may as well pass to the consideration of legislative bodies and the courts. It is not proposed here, however, to formulate a system. Systems are usually best developed when left to the operations of natural growth. But when we reflect upon the time wasted by legislatures in perfectly useless discussions and on the really little of general regulation that is necessary, we would be dull indeed could we think of no simpler means for reaching desirable legislative objects than our distracting political means. A properly authorized body of men with a motive in dispatch could

do in a week all that is legitimately done by legislative bodies in an entire session. As to the courts it is only a question of method in making judges; and as to those adjuncts of the courts, the offices where is kept a record of titles, transfers, and the like, they are already engaged in a deadly battle with the invading title-guarantee companies, with a reasonable chance for defeat at the hands of the invaders, and until the battle is ended it will not be worth while to waste time in discussing their utility.

Let the logic of our modern civilization hasten to its conclusions. Liberty has already gone too far to either retreat before political chicane, or to be forced back at the point of the bayonet. Men who are calling urgently for legislation against corporations, or "monopolies," as our co-operative economic combinations are called, are striking their best friends. Men who are pleading that the lands shall be put under political control, or "nationalized," are only extending their hands in order that they may be shackled in trebly-hardened steel; and every step taken to strengthen the political forces is only carrying us further and further from the true goal.

It furnishes a sort of melancholy amusement to observe the popular manifestations of opposition to economic organization. Such phrases as "corporate greed," "bloated monopolies," "combinations to plunder the people," and kindred forcible expressions are such common utterances that we have come to regard them as part of our daily literary regimen. They appear even in the leaders of journals claiming a high degree of intelligence, and are used to indicate the sympathy of those journals with the down trodden and oppressed.

Some of these phrases are the invention of demagogues, and some of fools. What are these bloated monopolies? Simply co-operative combinations, generally operating in some field that would be vacant but for their pre-emption; and their regime has brought about the most enlightened and most fortunate era in the history of the race. The western farmer is heard muttering his expletives against the railways. Yet those railways have enabled him to send a bushel of his wheat from his granary to New York for less money than it would have cost him to haul it to the nearest market town, likely to be far enough away, were the railways not available. But this benefits the consumer and not the producer, the farmer will protest. Doubtless it benefits the consumer; but if it does not benefit the producer to find a consumer it will take some-

thing stronger than his Sub-Treasury scheme to help him out of his ditch. In the case in point there would be no producer were it not for the railways. The farm from which this particular bushel of wheat came would be still a patch of wild land in the wilderness, hundreds of miles from any settlement. It would be on the trail of the aborigines. The North American Indian is the only being on the continent who has any just cause for complaint against the railways.

But as it has been with the railways so, also, has it been with the telegraph, the telephone, and the electric light, penetrating everywhere, carrying intelligence and promoting civilization everywhere, and meeting the public curses at every step. And those iniquitous coal combinations that are quarrying among the black hills of Pennsylvania and through the South and West shall not they too be remembered and execrated? Coal would be more than $50 a ton delivered in any farm-yard on the prairies were it not for the operations of these companies in enlarging the mechanical resources of production, and extending their railway connections. But the writer forgets. He said, but now, that there would be no farm yards on the prairies were it not for the railways, and it will be useless to speculate on what it might have cost to live there were not this wicked, plundering coalition between the coal companies and the railways maintained.

Men always crucify their redeemers. It is not a little curious that we should have had growing up around us for the last three hundred years the very co-operative system of which philanthropists dream, and that men should have yet failed to recognize its features. "Oh! but incorporation is the co-operation of capitalists," exclaims the reformer, "and it cannot benefit the men most urgently in need of benefits." But this is not true. It is wide of a just conception of the scope and achievements of incorporation. Incorporation is the co-operation of men who only wish to become capitalists, and who have largely succeeded. Ninety-nine per cent. of the corporations in successful being were built up mainly on promises to pay, and if the day ever comes when all men have obtained a secure competency it will be when incorporation has become universal. There is no other road leading to the universal abolition of poverty. State socialism might well have been the dream of a political despot. Even a despot, however, if honest, would think it rather a nightmare than a vision regulated by good digestion.

Political organization must go. It will doubtless endure for a

time yet, for in Europe it is heavily armed, and in this country, entrenched in tradition, it finds the conditions for its displacement not yet fully prepared. But we shall only act intelligently and wisely when encouraging the rapid absorption of its functions by economic agencies. Like all things rudimentary, political organization has had its uses. Our judicial code has grown to maturity under its hand, and this is something which the highest civilization may modify but cannot outgrow. This, however, is about all that can be said in its favor. Its machinery is oppressive, its brutality is manifest in its methods, its dishonesty is confessed, its corruption is patent, its plundering instincts are offensive to any honorable soul and its system of taxation is indefensible on any just theory of human rights. It is useless to say, too, that this political party is honest and that party knavish. All parties are knavish. They are made so by the relation of master and servant, a relation that underlies the whole political structure, and causes the one to be appropriative and the other secretive. Speaking generally, there will be no honesty in the world until the political incubus is removed, and men have been taught that all intersocial relations should be reciprocal, due to an interchange of services among equals.

BAD AIR IN THEATERS.

By C. S. Montgomery.

THEATER-GOING constitutes the chief amusement perhaps of a majority of the people in our cities and larger towns. Even villages have a masonic hall or school building that can be equipped with scenery and footlights, or an "opera-house," perhaps on the second floor of a wooden structure in proximity to the tavern or the livery-stable. Yet a series of fatal disasters was required to make even the best theaters of this country safe. The suffocation and cremation of nearly two hundred people in the Brooklyn Theater so dismayed the public that the attendance at amusements in halls was meager until the managers widened and increased the number of their exits, hinged their doors to open outward, built brick partitions between stage and auditorium, hung asbestos curtains in the arch, put wire protectors over gas-jets, placed sprinklers on the roof and hose in the orchestra space, and had firemen on duty about the premises at every performance. Theaters in America are safer now than they ever were before, and while a number of "death-traps" are yet among them, the disfavor these incur is slowly relegating them to service as shops, factories and warehouses.

Though theaters are safer than before, and perhaps more comfortable, by reason of widened seats and softer cushions, and certainly more agreeable to the eye, on account of the rich and harmonious decoration that is beginning to obtain, a defect has been largely overlooked that, if remedied, would tend to make play-going still more popular, and would increase the health and pleasure of audiences. That defect is the lack of air. The enjoyment of art depends more on mechanism than we realize, and in the matter of theatrical art it looks as if the stage mechanic was doing his best, with real tanks, real railroad trains, real bridges, real mills, real fire-engines and real buzz-saws to obviate the need for real acting. But it is a heated, humid, exhausted atmosphere—not the stupidities of realism that so often emphasize the barrenness and artifice of plays—that causes the audience to look bored and drowsy before the entertainment is over. Ventilating apparatus is at least as needful for the enjoyment of the drama as tanks, buzz-saws and engines.

It is alleged on scientific authority, and seems quite worthy of belief, that the air of theaters is the worst that is breathed, except in mines, for there are no other buildings into which people are so closely crowded for hours at a time. Prisons, barracks, schools, factories, hospitals, offices—places that are occupied constantly or which, being used in day-time, require lighting by many windows, that do some service as ventilators—are bad enough ; yet in many mills, with their thousands of operatives and with chemical fumes and floating dust in the air, the lungs take in less impurity than is received at the theater and the concert-hall. That the mill, with its air containing .15 per cent. of impurity, works more harm than the theater, with .30 per cent. of poison in its atmosphere—both illustrations being extreme—is due to the fact that the operatives breathe the .15 per cent. adulteration, say sixty hours a week, while the theater-goer, who perhaps attends a performance two nights in the seven, takes but six or seven hours of his mixture. Still, a lack of immediate bad results at the play does not excuse managers and owners from their neglect to furnish air for their patrons.

As the writer's business takes him to theaters and concert-halls from two to seven nights a week during "the season," he has often compared the condition of various houses, and he has been amused and instructed by the comment from people in the audience who were influenced unconsciously by the *malaise* produced by foul air and heat. The production of a drama at the Eighty-Fifth Avenue Theater would be seen by large audiences, attended by enthusiasm and would be spoken of afterward with general satisfaction. When, a week later, the same company produced the same play, with the same scenery, the same effects, equally good music and under ostensibly as favorable circumstance, at the Imperial Opera-House, the attendance would be smaller, enthusiasm less, the rush for "cold tea" greater between the acts, and there would be dissatisfaction with the piece, the acting, the orchestra, the waits and what not, the audience exhibiting a languor, restlessness and peevishness the causes for which were attributed to everything but the real thing : foul air. The first theater was well ventilated, the other not. To keep out street noises during a performance the few doors and windows in a play-house are closed, thus retaining the carbonic acid that is thrown from thousands of lungs and the odors exhaled from unwashed bodies and damp and unclean clothing, while the gas required for the illumination of the house and stage

is consuming oxygen all the time. Odors from neighboring factories, stables, restaurants and bar-rooms are not uncommon, and once in the writer's experience a panic was caused by the inability of the ventilators in a certain theater to carry off the smoke from a burning beefsteak that had been blown into the auditorium from a dining-room across the street. In two theaters that are almost within sight of the New York City Hall, sewer-gas gushes into the auditorium whenever the door beneath the stage is opened for the entrance of the orchestra. These various odors become so ingrained in the hangings, carpets and upholstery of an imperfectly ventilated audience-room that an airing during the whole of a summer vacation does not always suffice to remove them. Recently a theater was reconstructed, even to the rebuilding of the roof and one wall, but on the opening night a patron of the house added, after some words of praise for its improved appearance: "Yet I never knew a case before where a house could be torn out and rebuilt and retain the same old smell."

Artificial heat should be applied during the afternoon and shut off when the curtain rises, for warmth, increased as the night wears on, by the combustion of air in lungs and gas-jets, is enervating and renders the auditor subject to cold on emerging from the house. Provincial theaters, of the kind before referred to, being, as a rule, on upper floors, are bad in this respect, as well as unsafe in others. An actor relates that during a performance of "Hamlet" in one of these "opera-houses," the Queen stepped to Ophelia's grave (represented by a trap) to strew flowers on the corpse in the orthodox way, when the garlands were swept above her head, and after floating around for a time rustled down among the audience. There was a sausage-factory on the floor below, giving off torrid blasts, and the flowers, being made of tissue paper, were caught up by hot air rising through the grave, to the Queen's confusion and the hilarity of the public.

The obvious cure for bad air and excessive heat is not the opening of windows, which in theaters of this character are commonly few, by reason of the compact building of the neighborhood, but by the removal of dead air and the substitution of fresh air through conduits that may enter where expedience dictates: in the walls, under the galleries, or under the seats, the latter situation having an advantage for summer use, because most people enjoy the movement of cool air in warm weather if it is not strong enough to constitute an irritating draught. The ideal manager will cool the air

in summer as he must warm it in winter. In effect, a theater of the usual pattern is a chimney; given the heat, and the impurities rise roofward, where it wants only a fan, or even a roofed opening, to be rid of them altogether. Revolving cowls, formerly much employed, but liable to rust in their places or to whirl with a creak and a clatter, are falling into disuse. The trouble with most theaters is that both exit and entrance apertures are of insufficient area, and are masked or obstructed by reflectors, panels, ornaments or architectural details, and that no effort is made to secure circulation under the galleries which, rising to their union with the walls, create angular spaces that are *culs de sac* for hot and fetid air. To make up for the deficiency the doors and windows are opened in the daytime—an expedient of trifling advantage, for the only effective ventilation is constant ventilation—and during the hours when the house is shut the rancid and indescribable odor of a mixed assemblage, and, doubtless, micro-organisms as well, permeate the place and ingrain themselves into the textiles used about the building. It is especially desirable, at least where an upward exhaust is in use, that the stage should be ventilated separately from the auditorium, for the passage of air to a central exit in the roof of the latter draws out among the people the noxious fumes produced by chemicals employed in colored fires, the acrid smoke of gunpowder, so commonly used in melodrama, and the dust stirred up by shifting scenery, laying carpets, moving furniture, and even by dancing. A chorus of coughs and sneezes from "the front" is common after a battle episode or after a tableau that has been illuminated with red fire.

In a dwelling, occupied by few people, the change of air is a matter of less importance than in a place of public assembly, because, even with closed doors, there is an intake of air through cracks around doors and windows, between the boards of floors, through fireplaces, and even—by a curious process like the endosmosis of animal function—through the walls themselves; so that, while there may be discomfort, it is seldom that there is danger, unless there is a leakage of gas into the closed rooms; but in theaters the factors for vitiation are so multiplied that the increased spaces of a playhouse are not an offset to the increased manufacture of poisonous gases. A living-room is commonly regarded as ventilated enough if the carbonic acid in the air does not compose more than one volume in a thousand (for the air out of doors has one part in 2500) and in tenements, on winter nights, when every cranny is battened

against the cold, the ratio of poison has been found to increase to one part in 125, but some theaters are as bad as this or worse—or, it would be truer to say, some parts of them, for despite the diffusion of gases, the sub-gallery spaces retain more than their share of heat and the stagnant air seems to hold more than the common allowance of moisture. Water in suspension is the quality that makes summer humidity so much more intolerable than dry heat, and as it is given off in perspiration and exhalation it is as considerable an element in the discomfort caused by crowds as carbonic acid itself. Everybody who has had occasion to climb a ladder in a warmed and lighted or crowded room has discovered that the heat and discomfort near the ceiling is in excess of that near the floor, because heated air expands and rises, carrying impurities with it, and those people are in a similar position to the man on the ladder who have the ill luck to be placed in the top rows of the first gallery, with the sloping bottom of another gallery overhead acting as a conductor, and the angles of gallery and wall as pockets, for heat. In fact, the atmospheric conditions of a theater may best be realized if we fancy the building to be turned upside down, and to contain water instead of air. Wherever water would flow and stay under such conditions hot air will flow and stay in an upright receptacle, and the advantage of drains and a basin-shaped bottom in the one instance is duplicated by the advantage of ventilators and a domed roof in the other. The dome, however, while it is an advantage in the Metropolitan Opera-House, might injure the acoustic properties of a theater intended for spoken plays, and if there is a sufficient escape for foul air overhead that feature could be omitted.

An allowance of nearly 3000 cubic feet of air per hour to each person in a room is necessary to keep the atmosphere at standard purity, but for the short time occupied by a play or concert much less will suffice. Alfred R. Wolff, who has written an instructive pamphlet on the subject, says that he has succeeded in insuring an air supply in the Mount Sinai Dispensary—where unhealthy excretions make the largest volume desirable—of 10,000 cubic feet an hour, if needed. The more copious the air supply, the more the danger of draughts, and in the theater attached to the Madison Square Garden the provision of 1500 feet an hour is—or was—attended by a current that caused many objections from sensitive auditors in chilly weather. Again, when the air is rapidly freshened, there must be, in winter, so copious a supply of heat, as an offset, that managers will grumble at their coal bills. In the New

York Music-Hall, presently to be noticed, the supply of 2700 feet of air per hour to each person keeps the atmosphere at almost standard purity, and the effect of this on the audience is shown in the fact that there is little restlessness, drowsiness and nervousness, or, if these symptoms are manifested, it is when the artistic standard of performance fails to meet the expectations of the listeners.

The construction of theaters makes efficient ventilation really an easier matter than the ventilation of halls, club-houses and factories, for the step-like or terraced construction of the floor, needed to allow people to see over the heads of those in front of them, permits the placing of register-openings along the front of each terrace, and the decorations along the ceilings allow the concealment of outlets. The Brooklyn Academy of Music has a poor supply of air, but one arrangement of waste outlets is interesting, for a long strip under the gallery is not ceiling, as it appears to the eye, but perforated sheet-iron—a continuous colander—the warm air rising through the perforations and flowing into the ducts that have ample room between that ceiling and the sloping floor above. As this iron is decorated in the same manner as the ceiling, the holes are not apparent to the casual observation and few people notice them. Within a few years some highly ornate designs have been made for registers to be used in halls and theaters, but these designs are not yet in common use. Most ventilating apparatus is so ugly that it is surprising that artist artisans have not long ago tried to invest them with some of the outward graces that they must, in time, receive ; but one course is always open and commendable, and that is to paint or decorate the registers, whether for heat or air, in conformity with the color and ornament used on adjacent walls. The registers in our dwelling-houses are disagreeable things to look at because their shiny enamel is not in keeping with the softened surfaces of wall-paper and upholstery, and because their blackness is a harsh note in the color harmony that good decorators and housekeepers try to establish. Black should be avoided everywhere, except in the kitchen, and only there because it is hardly possible to do without it. In theaters, where it is desirable to produce a joyous or refined effect on the eye, the register should be brought into the color scheme of the house, and painted, bronzed or gilded. While the apertures will continue to show dark (unless, as in the Metropolitan Opera-House, gas is burned in the flues to assist the upward flow of dead air) the effect of blackness and harshness will be reduced to a minimum.

With the introduction of electricity a new system in ventilation has been made possible, and this has had its initial and successful trial in the New York Music-Hall. It is the reverse of the usual system in that it supplies at the top of the house and under the galleries, and exhausts at the floors. Where gas is employed for lighting, the heat created by hundreds of jets is so great that one element in an upward exhaust is already given, the hot air rising toward the ceiling in a constant volume, whereas incandescent lamps affect the temperature but slightly. The Music-Hall system may be set forth briefly, as follows: Air is taken in through a brick shaft seventy feet square and extending to the roof. Where it enters the building it passes over racks that can be filled with ice in summer, then crosses steam-coils, divided into sections, each with its separate system of valves; therefore, in cold weather they can be used singly or together, according as the quantity of heat desired is great or little. The pumping force is supplied by four blowers, two of them six feet in diameter, the others of seven feet, each blower being driven by its own engine. There are two main distributing ducts in the basement, each with twenty-four square feet area and made of iron, that carry the air into a system of smaller ducts built into the walls and that have their outlet in a perforated ceiling, so that the gallery, which is commonly the most uncomfortable place in a theater is, if anything, the best aired portion of this house. Every room in the building is fitted in this manner, but the arrangements permit the supplying force to be centered on any one apartment, the inlets for the main hall having an aggregate area of one thousand square feet—a surface that insures complete ventilation at an entrance rate of only one foot a second, no draught in that case being perceptible. The exhaust is made at the risers under each row of chairs, the rise being virtually an open fronted platform, resting on low arches, with an elevation of two to three inches, and the air, after flowing through the arches, passes into a vertical shaft of one hundred square feet area, whence it is sucked out by three six foot exhaust-fans, each driven by a separate engine. Not only does each gallery have a supply and exhaust, but every box is provided in the same way. The total volume of air brought into the building is nine million cubic feet an hour, the total aerated space being about two million feet, so that the theoretical time for a complete change in the atmosphere is less than a quarter of an hour. Yet the surfaces for distributing and removing are so large that there is no perceptible movement.

Like cures for other general ills, reform in the matter of the ventilation of public resorts rests with the people; let them show their preference for those theaters where health and comfort are considered. While the evil of ill-aired play-houses in England has been so great as to cause the appointment of a sanitary commission to investigate the subject, there is no need in this country of going to law about it. The law has so much more than it can or will attend to, that the only new law we want is one against law-making. It is not for a people's good that it should always have a man or a ring to do its thinking and acting. It must be allowed to learn a little for itself and to proceed upon its knowledge. If the matter of ventilation were left with the politicians we might have a repetition of that performance in Harlem, where they kept a new theater closed for several nights because the manager, who was not of the ruling class, would not adopt the particular kind of fire-extinguisher that somebody was interested in. Yet popular sentiment over-ruled them, and popular sentiment, when educated to the point, will accomplish the safety of our places of public resort and other things that now appear more difficult.

BIG BULL TUNNEL, SHOWING LAND-SLIDE AT EAST PORTAL, STEAM-SHOVEL ON THE RIGHT.

DIFFICULTIES OF TUNNEL-BUILDING.

By Emile Low, M. Am. Soc. C. E.

THE building of a railroad through a mountainous country is attended with many difficulties not easily appreciated by one who has not experienced them. Not the least of the obstacles encountered in the construction of the road-bed is the occurrence of land-slides and slips, often of great magnitude, which enhance the cost of building and also retard the period of completion, sometimes long after the expected date. Owing to the peculiar configuration of the ground the engineer may foresee to some extent points where land-slides are likely to happen, and it is possible at times to anticipate them and make adequate preparation for the quick removal of the fallen earth. But again there are places where the topography does not in the slightest degree indicate future trouble of this kind. No sooner has the work of construction commenced, however, than signs of forthcoming slips and slides are manifest, and when trouble of this kind once begins no engineer can predict its extent.

During the building of the Clinch Valley division of the Norfolk and Western railroad in southwest Virginia, through a section now undergoing a great industrial development, numerous land-slides were encountered, some of which were of considerable size. One happened just west of Pounding Mill station, where a deep and long cut had been excavated and the track laid through it. Early one Sunday morning, without any warning, a large amount of material slipped in from the upper side, completely covering the newly-laid track to a depth of twenty-five feet or more, and for a length of over four hundred feet. The removal of this slide occupied a month's time, although a large force of men were kept at work day and night.

Another very large slide occurred in the cut at the eastern approach to the Big Bull tunnel, on the same line of railroad. The entrance to this tunnel was located, as usual, in the lowest ground of a small ravine, the waters of which further down formed a small tributary to Russell creek, which latter in turn emptied into the Clinch river. The sides of the ravine were formed of steep slopes, through which at different points the natural rocks

BIG BULL TUNNEL, WITH STEAM-SHOVEL AT WORK REMOVING LAND-SLIDE.

cropped out and were plainly discernable. For this and other reasons no serious trouble was apprehended in making the excavation leading to the tunnel proper. But it was not long after the work was started until indications of slips and slides began to appear. The removal of material in making the road-bed showed that the bottom of the ravine was composed to a large extent of débris from the mountain sides. The overhanging rocks gradually becoming decomposed by the action of the elements naturally had found their way to the lower ground. Deposit after deposit, layer after layer, was thus formed and, of course, just as soon as an excavation was made through this loose material, itself possessing no great powers of cohesion, the sides slipped in. Then as the stratification of the underlying rock was somewhat inclined, little resistance was offered to the superincumbent mass. Extensive cracks appeared high upon the mountain sides, which gradually grew larger and larger, as the moving material was taken away below.

Much of the area covered by the land-slide had been denuded of standing timber, but here and there stood a tree, generally large. These kept growing upon the moving surface of the ground, and for a long time preserved a perpendicular, although they were slowly and surely borne down the hill. Shortly after operations had begun on the construction of this tunnel approach rainy weather began to be experienced. Water finding its way into the cracks above and then under the mass, the movement of the latter was greatly accelerated, the action of the water seeming to have the same effect upon the slide as grease upon the timbers of a ship's ways.

The contractors, however, kept bravely at work. No progress in the excavation of the approach was apparent for a long while —all the time was taken up removing the sliding material. Often on the return of the laborers to work in the morning, after having cleared away all the débris on the evening before, they were confronted with large masses of earth and stone. This would be the case especially after a hard rain. Nothing daunted, the men would attack the mass vigorously and haul it away. This experience was repeated day after day, and even month after month, until it looked as if the end would never come.

The slide with which the contractors were contending up to this time was located wholly on the south side of the cut. In time the north side also showed signs of movement which finally assumed larger proportions. Steps were then taken to arrest it, if possible.

BIG BULL TUNNEL, WITH LAND-SLIDE NEARLY REMOVED; WELLS LIGHT FOR NIGHT WORK.

Designs were made for a retaining-wall to be built of large stone, well laid and bedded in cement mortar. It was to be of ample dimensions, larger than usual for walls of this kind, for the reason that the conditions were also unusual. Happily a good quarry of suitable sandstone was at hand, from which the needed material could be easily and cheaply obtained.

When the stone had been quarried serious trouble was found in making room for the foundation of the wall. Sufficient space outside of the regular railroad formation had to be made, to do which a portion of the sliding material had to be cut away. During dry weather this was easily accomplished, the material standing nearly vertical. But about the time that sufficient space had been cleared and prepared in which to lay the masonry, a heavy rain would set in, saturating the sliding material, and causing it to fall in upon the nearly prepared foundation. Shoring up the slide with heavy timbers was resorted to, but generally without avail, as they were unable to resist the thrust. As soon as the sun would shine again, and often before, willing hands were at work repairing the damage. Success would at last crown their efforts and foot by foot the wall advanced.

At the same time other forces were at work in the approach cut, in advance of the masonry, their object being to reach the point where the tunnel proper began. This tunnel having been driven from the opposite end, had some time before been "holed" at the eastern portal. Many had been the dangers to which the men were exposed in the tunnel. Being driven through treacherous rock, the top and sides had to be supported by massive timbers, closely covered by heavy plank, to keep the loose material from falling upon the unprotected heads of the workers. When the excavation had nearly reached the eastern portal, it suddenly emerged from the loose and shaly rock which had been encountered from the beginning, into a stratum of blue clay.

Extraordinary precautions had to be taken here to avoid accidents. Advance had to be made by means of small drifts, which were afterwards enlarged. Heavy pieces of oak timber had to be used to sustain the top of the tunnel, inside of which the regulation timber was afterwards placed, but of such a cross-section or area to allow the building of a masonry arch inside of it. This was, however, never done. On account of the softness of the material, many of the timbers were subjected to an immense strain, and notwithstanding their strength and size, a number were badly split.

BIG BULL TUNNEL, SHOWING FORCE AT WORK WHEELING MATERIAL FROM INSIDE TO FLAT-CARS.

Additional timbers were put in to reinforce the others and to good effect. Owing to the descending grade in the tunnel, the water had to be pumped out by machinery. Often this failed and the water, accumulating, would fill the tunnel nearly to the roof. There were other mishaps, too, such as the breaking in of the overlying surface, near the eastern mouth of the tunnel. In driving the tunnel two coal-seams were found, one of which was three feet thick in places. It proved useful in furnishing fuel for the boilers of the air-compressor, which was used for some time in driving.

After several hundred lineal feet of wall had been built, the weather moderated and grew quite warm, although it was in midwinter. Rain fell day after day. The material behind the wall, which was already full to saturation, began to exert its power. Slowly, inch by inch, it moved towards the wall, unrelenting in its advance as an Alpine glacier, until by its pressure it produced its effect on the heavy masonry. Small cracks were first observed here and there, near the bottom. Then small pieces of stone began to spall off and gradually the wall started to bulge. Fears were entertained that it might collapse suddenly, and to avoid such a catastrophe it was decided to take it down. One by one its massive blocks were taken up, until not a vestige of the structure remained. About this time spring was ushered in, and with it more favorable weather. Better progress in the removal of the slide was made, and at last the desired portal was reached.

It was thought that all difficulties had been removed. But rain again set in, which brought in slide after slide, and consternation to the heart of the contractor. The slips were removed as fast as practicable. The effect of the overlying material was seen upon the portal of the tunnel. This portal was built of timber. This began to show signs of failure, and before it could be properly strengthened, part of it gave way. The remaining portion was then strongly braced, there being only one method, that of placing horizontal timbers between the opposite walls, which were thus firmly held in position. These timbers precluded the use of a locomotive, the height being too low for its passage.

At the points where the larger timber cross-section was put in, a smaller section was placed inside the larger one, making thus a double wall of great strength. By this time the tunnel had been finished entirely. Beyond was a deep ravine, to be crossed by a high trestle, the timber for which had to be run through the

BIG BULL TUNNEL, AFTER REMOVAL OF LAND-SLIDE SCAFFOLD CAR ON THE RIGHT.

tunnel. As locomotive power was out of question, hand and animal power had to be resorted to. One by one the heavy cars loaded with timber were slowly pushed up the heavy grade. This work being done in the tunnel, was performed in almost complete darkness. The trestle was soon finished and track-laying was ordered to proceed. But since the braces in the tunnel prevented the passage of locomotives the track under the braces was torn up and the bed of the tunnel lowered sufficiently to allow the passage of the iron horse. This was soon accomplished, the track relaid, the engine started and amid the cheers of the assembled forces and the shrieks of the steam whistle, the first locomotive passed into the Big Bull tunnel.

Track-laying proceeded rapidly and hopes were entertained that the terminus of the road would be reached before Christmas. But early in December another heavy rain-storm prevailed. Heavy masses of earth were dislodged from their resting places and brought down on the track, completely blocking the portal. It was entirely bottled up and not a vestige of the opening could be seen. A large force of men was set at work at once, to clear away the débris. They worked with a will and made good progress, but in a few days more material slipped in, obliterating entirely their former work. Recourse was then had to a steam shovel. Before it arrived a heavy snow fell, covering the ground to a depth of several feet. Naturally great difficulty was experienced in getting laborers to do the work, on account of the inclemency of the season, besides which the Christmas season intervened. Gradually, however, a large force was assembled, and after New Year's work was resumed in earnest. The steam-shovel was set to work and slowly but surely it ate its way towards the portal. Many a time, when success seemed to crown all efforts, heavy rains set in and brought in more slides, and as often they were removed. The work was of the most discouraging nature and it seemed as if though the end would never be reached. But all things come to those that wait, and after four months battling the portal was reached at last. Some little clearing out of the material which had found it way inside the tunnel proper and it was again ready for the passage of trains. And thus after three years and a half of hard fighting Big Bull was subjugated and brought into the service of man.

BIG BULL TUNNEL COMPLETED.

EDUCATION FOR THE WORKSHOP.

By Frederic A. C. Perrine, D. Sc.

YESTERDAY and to-day in an American machine shop are contrasted by nothing more than the introduction of the practice of theory and school-book methods in these later times. The desire of every apprentice to-day is not so much to learn the tricks of the trade and shop secrets, or even the complete mastery of every tool, as to know the underlying principles and uses of the articles with which he is working: it is this which has made him the inventor that he is, and it is this which has made him an inventor of labor-saving and skill-saving tools, rather than an intense student of the tools originally put into his hands. Possibly this tendency has narrowed the number of our most skilful workmen to those who are born mechanical geniuses, but it has had the further effect of making national, labor-saving machinery which will turn out a product more perfectly adapted to the end than that of the most refined mechanic.

With the Centennial and Paris Expositions, attention to this difference in American and European manufactures was attracted by the comparative tests in watches and other similar articles, in which superiority had only been attained in the past by tedious and life-long labors, and it was the wonder of the world that, without the long-taught families of workmen, such a result could have been produced. At the introduction of the electric light, when new engines were required of great capacity, perfection of workmanship, and steadiness in running, our builders attacked and solved their problem.

Of the numerous engines designed those which survived are those which have followed most closely the theory of the steam-engine in kinematics and thermodynamics. The new race of engineers and workmen are school-bred and college-bred, and, even from the crude point of the salesman, a correct theoretical design is a necessity.

Such being the genius of our time, the thought naturally recurs: what knowledge is of most worth? Spencer has broadly answered: "Science!" and has proven his contention. But specifically what science and what application of science are fitted, not to the stu-

dents of a college, but to the boys in a workshop, to whom remain, after the daily task, only the hours of the evening? Almost without exception this question has been answered in one way. Such monuments as the Cooper Union were built solidly on the answer, and never before, in the history of education, have such strides been made in the same direction as those now being taken in our colleges, notably those ancient bulwarks of the classical training for culture. Every mail brings to the anxious father seeking light on the future of his son about to choose his course for life a mass of circulars of this college and that college which has added a workshop or new dynamo to the electrical-engineering course, the mechanical department, or some other technical branch, till one would think that a multitude of machines had deposed the great names and able men in the leadership of our rising generation; and the answer to the question "What science is of most worth?" comes back to us on every side: "The science of getting on" and the application of all that has been done in the past days.

No one should frown upon this necessity for living, and the teaching which will enable one to earn more easily the means of a livelihood, and it may be a subject of congratulation that into the dreary college days something besides football has been introduced which is able to show to the learner the goal to be attained. To no one who has not recently stood the strain can the dreariness and seemingly hopeless yearning of the days of classical training be as real as they are to the student, and it is small wonder that he welcomes tools and the machines of the work-a-day world, which seem to be putting him into contact with what is to be the purpose of his after years. At present the machines are toys in the hands of the scholar, with which he thinks himself to be achieving wonders; and, until this new learning shall be systematized with the older classical and philosophical training, there will be heard no yearning from the midst of an inexpressible *ennui;* nor is there need, if the balance is not lost and culture for life neglected in the training for a living, that the *ennui* should come in either youth or age. Just as surely as the classical student, after years of poring over books of dead letter, yawns as his hair grows grey in the task, just so surely will the wish for something above, beyond, and underlying his machines be present to the machinist when, after years of turning and boring and fitting, he finds his boys bringing home from school the solutions of the problems he and his shopmates have been puzzling over for so many years. To

both of these men there might have been a happier life, if not a more useful, had their early training led them together, and given each the power to throw light upon the tasks of the other.

For the student a tempering of workshop methods and results was needed, and to the shopman a mellowing through principles would have given insight. Thus stated, our problem answers itself; that, for the apprentice in the shop, the training needed is not that of the manual school, but that of the technical school; if he is in the shop, he is learning fast enough the workshop methods, and, if he is desirous of learning a trade, the workshop is the best teacher and the most complete school; there he can learn the methods used and the results required. The standard of work is neither above nor below the practical, and there is the quick training of eye and head, which cannot be acquired so readily through the medium of mathematics. The efficient workman may cut his metal at the rate taught in feet per minute, but no mental arithmetic can be so quick as his eye in choosing the speed, and no mechanic can be finished till he has deserted the calculations and trained his eye to accord with them. That the apprenticeship system in its completeness has been destroyed for some years may be a misfortune, but this is the work of the *Zeit-Geist;* the apprenticeship system is gone because there is no longer a necessity for it; not only on account of the increasing perfection of machines, but also on account of the training in intelligence our workmen have undergone.

The workman with a light hand and well-balanced brain can acquire to-day a skill of touch which the beer-soaked apprentice of fifty years ago could have equalled only by a ten-fold expenditure of time in training.

The trades-unions, in their conservatism, have fought for this retention of the system, but their younger members rebel, consenting in these days to remain apprentices only in name, and paying for the prescribed time, which has been steadily shortening and, in the higher classes of the machinist trades, is gone altogether. It is folly, then, for the teachers of the people to run so counter to this well-defined tendency of the trades; and if a manual school be established, it should not be with the aim of re-introducing old systems. Skill enough for the present time can be acquired in the shop in daily handling the tools and their products, but the workman sadly needs light—light which he can never get from his own experience.

To read the books which would most help him, he must have a grasp of mathematics, of physics, of chemistry, and of those grand truths and methods of science which have done so much towards making our modern world.

The workman in the electric-light company will not wind the armature with defective wire, will not leave half-soldered the joint in the line, or unscrewed his binding-posts, when the absolute and necessary result is well known to him. The puddler knowing the chemical processes of his art is surely none the less able to make a ball of perfect iron, and, as a learner, will acquire the art more quickly. Josiah Wedgewood recovered in England the "lost art" of Italian pottery by studying intelligently and in the light of modern learning his English clays. The Bessemer process is no product of mechanical skill; and we might cite as examples every modern advancement, showing that it is the application of book-learning and theory which have made our modern processes so perfect.

Bald "pure science," as it is called—science for its own sake—would undoubtedly be found too abstract for the conception of the artisan; but without surrendering any of its exactness, mathematics should be taught as it bears upon the daily problems; elementary geometry, algebra and trigonometry would easily lead up to the study of mechanics and machine designs, and thence, by the man's own inclinations aided and directed to a moderate extent, to the several branches of machinery and its theory.

A whole field opens out here, in which the tendency is to attempt too much and to confuse the artisan with the engineer just as merges the natural distinction between them, which is only established by each man's capabilities and industry. Founded on mathematics, a course in physics specializes itself at once into the training for the many classes of workmen in the electrical trades and for steam and water handlers. Chemistry completes the trilogy, applying itself to almost all the various trades in greater or less degree, and, as an occult science, cannot be acquired outside of the books and schools by men who are busy workers. In the rubber-mill there are unsolved chemical problems; in the potter's trade a second Wedgewood could accomplish the same wonders: while in the arts of dyeing, tanning, and brewing, there is present every day to the mechanic a gigantic laboratory with test-tubes fervid with chemical reactions. For the success of the inventor, indeed, there is a necessity that the many should live in the dark as

to the secrets of nature, but we look toward the perfection of the life of the mass rather than the well-being of the individual and for life as well as for a living. There is need that we teach the boy in the workshop something beyond the mere performance of his tasks, knowing that, if he becomes too well educated to continue in the old life, it is because he was worthy and we have aided him to prove his worth ; knowing that, if he is born to his trade, the greater insight we are affording him to its processes is but making the abler tradesman of him ; never afraid that to the true man an education will be a source of dissatisfaction, but rather confident that it will be a means of ennobling himself and his occupation in all men's eyes.

I would have the night-school, then, teach theory and the principles underlying the daily tasks, and in its completeness not even neglect a modicum of more refined culture, scientific art. So educated, the workman will not stand still as a perfected machine, but will leave the impress of his brains upon his daily work and in his almost daily advances on the methods of yesterday, and thus there will be no loss of the American supremacy in mechanics, of which we are so proud.

In another field beyond this perfection of the mechanic in his mechanical art and education is needed by every worker in every shop of our country, in order that we may continue the happiest people of any time, indeed, yet more that we may not become the most unfortunate and unhappy of nations. The American mechanic is a thinker in all that touches him in life, and as well as becoming an inventor of tools, his training as a politician has made him an investigator in the line of social economy. Often it seems as one becomes familiar with these men in the shops, and their studies, that a familiarity with the social problems is much more common than amongst those who have devoted their lives to their education and the solutions of the many social questions will come from their ranks and heads, rather than from the thinkers we are accustomed to look upon as the prophets of the future. These men have a practical lever upon the destiny of their fellows in the shape of their trades unions and other associations, as well as their individual right and power as voters, nor are they disposed to neglect the use of this leverage or to solve the problems narrowly.

The leaders of the great strikes may indeed be deficient in insight, but these combinations and disturbances of trade are not entered upon in order to settle single scores or differences, but

rather with the grand future in view and a determination to settle the world's problems upon lines of definite policy.

The key-note of almost every such line of policy is some right they see trampled upon, and the war-cry to-day, as in the time of the French Revolution, is for "Rights and Privileges." Every man's right is another's duty to grant, and no world founded upon such rights can be separated from a world actuated as well by a sense of duty to our fellow.

This view of the case is by us all too much neglected, and by the workman is unseen because of not being pointed out to him; surely enough preachers and politicians have gone down to him and told him of his obligation to the world and the race, but as he sees a world of injustice founded on his labors, it is little consolation to him to be told that the fruits of his labor, of which he often sees himself deprived, were taken for the benefit of humanity. It is not necessary to speak the word in order that the true conclusion be drawn, but the facts must be known as well as the scientific method which compels to the true solution of the problem. Duties are not shirked from dishonest motives, but rather in the workshop from a blind ignorance of their consequences, and the assertion in their place of rights which have become the supreme conception.

To do your best work and good work, whether you live or die for it, is the highest diction of a training in pure science, and can be attained and maintained as an ideal through no other studies.

No geometrician will shirk the most complete knowledge of the conditions of his problems and their inevitable consequences, and whether that problem be of lines and angles, or of lives and happiness, whether it covers a school-boy's slate or the face of the world and reaches up to heaven, he will bring the solution of the problem honestly and completely, whether it be one of joyousness or death to him. From his training in cleanliness and in perfection in proportions, the chemist will weigh out life exactly, and will know better than any other man the enduring harm of a smirch on a future.

The gain in truthfulness and reverence which is his who knocks earnestly at the door of nature for her secrets, has been the text of too many lay sermons to need many words upon the subject, and I wish to call to mind all of these hopeful views of learning to apply them anew to the conditions of the workshop, where there is too much even yet of the relation of slave and task-master between employer and employé.

Rights exist and need no one as their champion, but duties and courage and humanity are sentiments too easily neglected, but which yet are the crown of life and the civilizing influences on the race.

That the slighted ball from the puddling furnace may involve a railroad disaster, and the plugged casting a foundered ship; that the neglected vat may produce financial ruin and the idle mechanic a commercial crisis, are all but too little felt and recognized by the very men in whose hands the doing or non-doing of such things may lie; not, indeed, that they are incapable of such high conceptions, but there is little in the attitude assumed by their seeming superiors which could teach them to be other than handlers of machines, and the mission of reformation must be carried to these earnest seekers for light, by the disciples of scientific culture.

True, indeed, not every scientist is truthful and devoted to the interests of others, and true also is it that a life may be too candid for plain sailing amongst the perils of business, but this trust and truthfulness comes only into the world timidly and little by little through the spread of their principles, and though to-day it may be true, as has been stated again and again in discussions on education, that much training for the business man and the mechanic unfits them for successful careers, and that the college-bred man is bound to be poor by the side of the less highly polished student at the school of the world's hard knocks, yet it is not on the education and its training the blame must be laid. If that man knowing best the laws and facts of existence, and acting on the precepts of his knowledge, be not the successful man, the conclusion must inevitably be drawn that the conditions of our time are false and temporary, and by knowledge must be altered, and we must learn to know and face the laws of our being, and so only escape destruction through them.

In no walk in life can it be possible for such training to be more effectual than in the workshops of the country.

There are the men upon whom we are building the fabric of our state; they are pre-eminently our citizens; to-morrow they may produce the leader of the world, but to-day they are the masters of state, and as sturdy men, capable of education; the truths of pure science they need for the perfection of their workmanship, and the methods of science we should give them to teach them duty and honesty and make them worthy of the charge put upon them.

ELECTRIC STREET-RAILWAYS AS INVESTMENTS.

By Lemuel William Serrell, M. E.

IT is recorded that when the question "You must be making handsomely out of your canals?" was put to the far-seeing Duke of Bridgewater, he replied: "Oh, yes, they will last my time, but I don't like the looks of these tram-roads—there's mischief in them." While the Duke might have foreseen the conditions that surround us to-day, Thomas Gray was the first to boldly advocate the building of steam-railway lines to distant points. But he, like many others on whose ideas thousands have become enriched, remained forgotten, and in poverty was forced to sell glass on commission for a living. How many railroad men to-day have ever heard of him who was first to conceive our magnificent system of steam-railroad transportation? His ideas, published from time to time, started many thinking, and as one of the results the formal commencement of the Baltimore and Ohio railroad took place on July 4, 1828, at which time the venerable Charles Carroll, then the only survivor of the signers of the Declaration of Independence, laid the first stone to mark the beginning of the work. From that beginning has proceeded the development, from the old tram-roads, over which rude cars on wooden rails were drawn by horses, of our magnificent system of steam-railroads to-day.

But for years the horse remained in front of a car as the only means of transporting people through our cities, and it was not until the introduction of electricity for this purpose that any marked improvements were made in this character of travel. The early experiments in electricity were interesting only from a scientific standpoint, as the source of electricity was the primary battery, and it was not until the invention of the direct-current dynamo that a means of generating electricity was devised, by which it could be distributed economically in a way that would make electric-traction practicable.

Of the forms of motive power that have been tried, to take the place of the horse, may be mentioned the gas and compressed-air motors, the cable, the electric-conduit, the storage-battery, and the trolley-road. The gas and compressed-air system are probably the

oldest, and for the past twenty years they have been pushed by their advocates and put upon roads, on trial, all over this country and Europe ; yet to-day there are no roads in operation by either motor—except experimentally—to show merits sufficient to cause their adoption.

There is no doubt that a suitable electric-conduit will be invented some day, but we need no better instances of its failure in the past than the abandoned conduit in Fulton street, New York, and the receipted bills of the West End Company of Boston, for the sale of the old iron that had once been used for a similar purpose.

The history of the storage battery gives the same results. It has been favored because it is an ideal system. There is scarcely a large city in the country where storage-battery cars have not been run experimentally, and yet it has not been adopted because it has proved impracticable, while the trolley-road, starting side by side with the storage-battery, with all the maledictions that could be hurled upon it, has established itself as the only practical method of electric-traction. The reported deadliness of the overhead wire has been proved a myth, and the objections to the system now are only æsthetic ones.

Let us look briefly at what has been done in the case of electric-trolley railways. Scarcely five years have elapsed since it was shown that the trolley system could be made a practical success as a means of propelling cars, and yet to-day more than 450 roads are reported as being operated by electric power, having a total mileage of more than 3600 miles and employing nearly 5800 motor-cars. Thus about three-eighths of the street-railways in this country are now operated by the trolley system. The old tram-rails are being replaced by better forms of construction, handsome cars measuring thirty feet in length replace the old style of horse-cars, and a speed double that attainable with horses is used with perfect safety in equipping street roads with the trolley system. Many of our large cities are already so equipped and it is estimated that $155,000,000 has already been expended. It has also been proposed that the experiment be tried to ascertain if electricity cannot be used practically to supersede steam on railways. Many of us doubtless will see this accomplished, although probably not until electricity can be generated directly from coal, without the use of the steam-boiler, in which event a train of cars so propelled, it is estimated, will move at least five miles for the same cost that is now required to move a train of the same weight one mile by

steam. Neighboring cities, ten and fifteen miles apart, have been connected together by such roads. A fifty-mile electric-road is proposed between Worcester and Providence ; another forty miles long is being built between Tacoma and Seattle, and an electric-road is projected between Chicago and St. Louis, to be built in a straight line, over which a speed of more than a hundred miles an hour is expected to be attained.

Thus we see developing from the old tram-roads a system of roads operated with electric power which bids fair to be of as great, if not of greater, importance to the world than the present steam-railroads, which are a development from the same original tram-road. The census of 1890 shows that the street-railways of New York City carried during the year 2000 million passengers, or more than the entire population of the globe, and about four times as many passengers as were carried on the steam-roads of the entire country, this number of passengers having been 250 million. The steam-railway track-mileage is about sixteen times as great as that of the street-railway. The street-car lines in the cities of Boston, New York and Philadelphia carry more passengers per annum than all the steam-roads of their respective States. Cable-roads are usually built in crowded cities, where it has become necessary to dispose of horses, and the right for the overhead wire could not be obtained. No one would think for a moment, however, of building a cable-road if a franchise could be obtained for a trolley-road, as they cannot carry any more people, route for route, than the electric road, and cost nearly ten times as much to build.

The value of street-railway securities as safe investments is only beginning to be generally appreciated. In the past they seldom have been offered to the public. The fact that a road once located upon a principal thoroughfare in a city, is fixed upon the line of personal travel, which cannot be changed by the building of a parallel line upon another street, has not been brought forcibly enough before us to be generally appreciated. The fact is that a street-railway located on a principal thoroughfare, equipped with modern appliances for rapid transit, runs upon a highway through which people move, and they will ride on these cars rather than those of a parallel line in another street. The securities on such a property, when once on a paying basis, make a safer investment than steam-railroad bonds, the value of which are always liable to be impaired by rate wars, and by the building of parallel lines. Steam-railroads run between terminals, and not upon fixed lines of

personal travel, and where terminal facilities can be secured in cities, parallel lines are always likely to be built.

When a city reaches a population of 25,000 its growth and business prosperity may safely be expected to increase steadily, and the securities on street-railroads on a paying basis, and located as above described, are sure to rise in value. The tendency of human nature is also to locate and build close to this line of travel, causing the thoroughfare to become more important as the city grows.

The introduction of electricity as a means of rapid transit has done and is doing much to bring this class of securities before the investing public, and the list on page 222, giving the recent market quotations of some of the leading street-railway stocks and bonds, shows how such securities are looked upon by those who know their value.

The remarkable cheapness with which electric-roads can be operated as compared with horse-roads and the cheapness of the first cost as compared with cable-roads has led to the building of more than 3600 miles of such roads within the past five years. The earnings for the capital invested are larger for electric street-railways, than for steam-, horse- or cable-roads, and the securities on such properties are now beginning to attract the attention of the general public. The cost of building and equipping street-roads varies considerably with different local conditions. A comparison of the average cost of building and equipping cable-, electric- and horse-railways per mile of track, taken from the recent census reports, is given below:

Cable-roads,	$350,000
Electric-roads	30,000
Horse-roads,	41,000

The above represents a fair average for paved streets in cities proper. For suburban travel the cost per mile of track and electric equipment need not exceed $20,000.

The earnings of the various properties may best be expressed by the ratio of their operating expenses to their gross receipts. It is hard to get figures giving this ratio for cable-roads. The only ones published that I have been able to find are for Denver, Colorado, where this ratio is reported at 77 per cent., while for the electric lines owned by the same company it is reported at 55 per cent. Cable-roads cost almost as much as elevated railroads, yet in some places they both are bonded for more than $1,000,000 per mile and have dividend-stocks. The same ratio for horse-railroads

we find, by taking the average of over fifty roads from the reports of railroad commissioners, is 80 per cent.

A large number of reports have been published, on electric-roads, placing this ratio at about 50 per cent. From my own investigation I have found that these figures were true for certain months, but they do not represent the average for the whole year, and that in the section of the country where snow must be removed from the tracks, the year's average is from 60 per cent. to 65 per cent. The increase in the net earnings in cities like Boston per revenue car-mile run for electric-roads over horse-roads, averages 50 per cent. This enormous increase of earning capacity has given a well-merited "boom" to the electric-railway, but at the same time has opened an opportunity for objectionable speculation, the same as surrounded the steam-railroad, which caused the wrecking of so many fortunes and gave the opportunity for great railroad steals, followed by reorganizations and "freeze-outs."

The Duke of Marlborough in speaking of American railroads says in substance that almost all the railroads in this country have passed through a period of private manipulation by the early promoters, who originally floated their gold bonds on the European market, built the roads as cheaply as possible, advertised the advantages of their land-grants in Great Britain and Germany, induced immigration, and forced their capital stock, which did not represent as much money as the paper on which it was printed, on all the stock markets of the world, realizing great fortunes. All this would have been perfectly proper if the earning capacity of the roads had warranted it, and protection had been given to the bondholder, but in many cases the roads were over-bonded, and the managers were unscrupulous people, who, when they had the control of the voting tickets caused the roads to default in the interest of their bonds, the financial prestidigitateurs thus causing new fortunes to be made and old ones to be lost.

Many electric-roads have been built and bonded for more than they cost, the stock being all "water," but most of these are reorganized horse-roads, whose earning capacity has been such as to warrant a large bond, though in some cases the over-zealous projectors have not left sufficient margin for maintenance, repairs and renewals. In such cases, if the management is honest and capable, the roads probably will yet be brought into a sound condition.

Electric-railway securities are comparatively a new thing, and, being so little known, are looked upon as not being as desirable,

The skepticism that has surrounded the mysterious action of electricity has not furnished the same fertile basis upon which to float securities as the development of commerce by building steam-railroads. Therefore the people who have attempted to make more than their share of profit by aping the plan upon which steam-railroads were built probably will have a heavy burden to carry for some time. But there are elements of security in a well-selected street-railway bond which make it as good an investment as any waterworks or municipal bond, and safer than steam-railways.

Bonds on electric railways may be divided into three classes:

1. Bonds on new roads built from franchises, whose earnings are problematical.

2. Bonds on reorganized horse-roads whose net earnings with horses have not been sufficient to pay the interest on their bonded debt, when equipped with electricity.

3. Bonds on reorganized horse-roads, whose net earnings with electricity are sufficient to pay the interest on their bonded debt, when equipped with electricity.

Projectors of a road of the first class need not expect to sell their securities, except at a great sacrifice, until the road shall have been in operation long enough to demonstrate its earning capacity, and even then the securities should not be purchased without careful personal examination and endorsement by responsible parties.

Bonds on roads of the second class may be considered as very good and safe investments where the interest charges on the bonds does not exceed by more than one-fourth the net earnings of the roads when operated with horses. Capitalists will run very little risk in undertaking the financiering of roads of this class, when the above restriction is observed, and the cities are of good size and well known. The stock on such roads probably will be dividend-stocks from the very start.

Bonds on roads of the third class are of the best class, and are not excelled by any other form of investment. Such bonds should sell at a premium and find a very ready market, and the stock should be worth par.

When the elements of security that surround street-railway bonds become better appreciated they will be regarded among the best and most readily negotiable securities before the public. In cities from 25,000 to 40,000 people a comparatively local market must be sought, but well-selected bonds on roads in cities having a larger population should find a ready sale with the general public.

RECENT PRICES OF STREET RAILWAY SECURITIES.

CITY.	NAME OF ROAD.	STOCK. Par.	Bid.	Asked.	BONDS. Bid.	Asked.	MOTIVE POWER.
Albany, N. Y.	Albany R. R. Co.	100	112	115	103	...	Electric and horse.
Baltimore, Md.	Baltimore City Pass. Ry.	25	60	70	110½	111	Horse.
Brooklyn, N. Y.	Brooklyn City R. R. Co.	100	178	180	107	108	Horse, changing to electric.
Chicago, Ill.	Chicago " " "	100	324¼	325	99	...	Cable and horse.
" "	North Chicago City R. R. Co.	100	500	...	111	112	Horse.
" "	West " " " "	100	630	...	101	102	Cable and horse.
Cincinnati, O.	Covington and Cinn. R. R.	50	120	123½	110	114	Electric.
Cleveland, O.	Brooklyn St. R. R. Co.	100	170	175	...	...	Electric.
" "	Woodlawn Ave. and West Side	100	145	150	...	...	Horse, changing to electric.
New Haven, Conn.	State Street Ry.	25	103	105	105	107	Horse.
New Orleans, La.	Carrollton Ry.	100	118	122	113½	..	Mule.
New York, N. Y.	Broadway and Seventh Ave.	100	193	200	103	105	Horse, changing to cable.
" "	42d St. and Grand St. Ferry	100	245	250	102	105	Horse.
" "	Third Avenue	100	220	230	108	111	Horse, changing to cable.
Pittsburgh, Pa.	Pittsburgh Traction Co.	25	52	54	104¼	...	Electric.
Providence, R. I.	Union R. R. Co.	100	186½	190	...	...	Horse, changing to electric.
St. Louis, Mo.	Benton-Bellafontaine	100	100	...	102	102½	Electric.
" "	Missouri R. R. Co.	100	230	240	102	105	Electric.
" "	Union Depot R. R. Co.	100	200	250	104	105	Electric.
Springfield, Mass.	Springfield St. R. R. Co	100	200	225	...	...	Electric.
Washington, D. C.	Washington and Georgetown	50	250	275	101	104	Horse.

WAR A HUNDRED YEARS HENCE.*

By Emile Gautier.

THE editor of the *Revue Rose*, Dr. Charles Richet, has just had the curious idea of forecasting the future by that inductive method which, since Bacon's time, has served as the basis and the instrument of experimental science, and of which, one might say, it is the very soul.

The fact is that historical and social as well as physical phenomena are dependent upon immutable pre-established laws. No more here than elsewhere does nature proceed by leaps, surprises, or dramatic moves, rather than by slow and gradual stages. Consequently, to one who knows how to trace the logical filiation of events, the present, issuing from the past, necessarily contains the germ of the future.

Starting from these premises, the ingenious *savant* has concluded that the evolution of a civilization can be calculated in advance, as we predict an eclipse, as we diagnose the progress of a disease, as we estimate a standing crop, or as we determine the successive positions of a moving body in space from the elements of its curve. He has concluded that from the present status of men and things, their nature and their tendencies, it cannot be impossible to prophesy their future destiny with relative certainty and precision.

Hence a suggestive series of articles outlining the picture of the probable situation of the civilized world in 1992.

Such anticipations, no matter with what degree of scientific scruple they may be arrived at, evidently can never be anything but mental amusements. The problem is so complex and involves so many indefinite and unstable factors that the most subtle reasoning cannot fail to be tinged with fancy.

Therefore I shall beware of following M. Charles Richet in all the hazardous vicissitudes of his journey through the unknown. For the present, of all of his prophecies I note and criticise but one—that concerning future international relations and the question of war.

"A hundred years hence," says M. Richet, "perhaps no tribunal

* Translated from "Le Figaro."

will yet have been established for the peaceful settlement of differences between peoples, and nations possibly will continue to stifle under the burden of an ever heavier armament. But standing armies inclusive of all citizens will scarcely exist except as schools of discipline. They will no longer fight, war having finally killed war perforce of horror. The means of destruction, in short, will have become so refined and formidable that there will be no desire to make use of them, no thought even of doing so."

I am not unaware that this opinion, to which M. Richet has simply given a scientific dress, is widely prevalent. Nevertheless it is impossible for me to share it.

In my view, indeed, it rests upon a fundamental illusion, upon a false appreciation of things.

Though it may not be unlikely that at some day or other—a distant day no doubt—war must cease, this desirable result will not be prompted or even hastened by the most wonderful engines devised by modern science. In fact, it is not correct that progress in the art of destruction serves to render war more murderous or more horrible. *On the contrary!*

This seems like a paradox. Nevertheless nothing is easier to demonstrate.

The farther we go, the more perfect become our weapons, gaining in precision, reach, and power, and the fewer are the victims of war.

Soldiers no longer see each other, no longer touch each other, no longer come into that immediate and brutal contact in which one of the adversaries (if not both) loses his blood and his skin. It is at a distance of miles, over insurmountable obstacles—rivers, hills, woods, etc., which obstruct the vision—that melinite and smokeless powder talk and that uncomplimentary greetings are exchanged in the shape of balls, shells, or shrapnel.

Now, this new tactics seems destined—fortunately!—to make more noise than work and to cause more moral disturbance than material havoc.

Is it known that the classic estimate made by Marshal de Saxe in his day that to kill a man in battle a weight of lead is required equal to the weight of his own body—is it known I say, that this estimate has fallen considerably below the reality now that weapons are what they are to-day?

M. de Chesnel has calculated that no less than 280 pounds of lead are required to kill a man, and a comparison of the number of

cartridges burned during the Franco-Prussian war with the losses suffered on both sides shows *thirteen hundred* rifle-shots for every dead soldier.

With the repeating rifles the difference will probably be greater yet, because the combatants will no longer expose themselves as formerly, in compact masses, in the open field ; because there will be very few cavalry onslaughts, very few mad bayonet charges, very few bold attacks, and still fewer protracted stands before the mitrailleuse ; because it will inevitably be necessary to learn to deceive death by utilizing the slightest means of shelter and to gain time and ground at the least risk. Have they not recently been discussing in Denmark a sort of screen singularly resembling the legendary "tortoise" which the Roman legions formed, in Julius Cæsar's time, by symmetrically raising their shields above their heads ? Are they not talking of furnishing soldiers in advance with shovels and picks, with a view to improvising intrenchments upon the battle-field, as if henceforth each sharpshooter or each gunner would have to be in his own person, if not an engineering sapper, at least a navvy, and as if the chances of victory must henceforth be measured by the quantity of earth displaced rather than by the quantity of powder burned ?

Such precautions were scarcely thought of in the days when, rifles carrying but 150 or 200 yards at the most and requiring a relatively long time for loading, fire was not opened except at a distance short enough to permit each marksman to choose his living target, follow it with his eye, and take deliberate aim at it. At that epoch Marshal de Saxe may have been right. But this was long ago !

As for shells, one needs but to have participated in or witnessed the smallest skirmish to know that they do much less damage than bullets, much less even than those balls which they used to fire horizontally, quickly sweeping away whole rows of men, whose places it was necessary to fill by "closing up the ranks."

In reality, much fewer soldiers fall in a duel of artillery or in a fusillade lasting a whole day than in a sword combat of half an hour, in which no blows are wasted.

The battle of Gravelotte, one of the most murderous of the century, cost the conquerors no more than 4449 killed and 20,977 wounded—which, be it said in passing, is a figure notoriously inferior, according to official statistics, to the number of victims mowed down in a single year, in the German empire alone, by the

fatalities of industrial labor. Now, I lay it down as a fact that, if two savage armies of a hundred thousand men each, armed with tomahawks, were to be confronted with each other during one forenoon, more than twenty thousand bodies would be left upon the field.

Remember that frightful combat of the Champs Catalauniques, which cut down more than three hundred thousand men, and literally poured upon the soil real rivers of blood.

We shall see no more of these butcheries, just as we shall see no more of the wars of a hundred years ago. Modern warfare is not compatible with them, and its worst devices for assassination are almost humane.

I repeat, the frightful means which it calls into action are going to give birth to an entirely new system of strategy, which will transform war into a sort of continuous manœuvring on a grand scale, into a game of chess, in which calculation will play a much greater part than the brutal shock, and in which the aim will be rather to paralyze than massacre the enemy. To cut off the adversary's communications, to starve him, to ruin him, to disorganize his forces, to drive him to the alternative of capitulation or inevitable extermination—such will be the war of to-morrow, carried on at great distances, along an immense front, scientifically, methodically, with the aid of steam and electricity. That cannot cost as many lives as in former days, when they fought hand to hand.

In this metamorphosis of the art of war all those formidable engines, which are constantly being perfected, will serve principally by the terror which they inspire, by the demoralization which they spread on the one hand and the ardor which they communicate on the other. More effective surely than their predecessors, they act nevertheless at greater distances, and there is greater opportunity to guard against them.

I suspect that a hundred years hence war will be a thing of the past. But if so, our grandsons will owe this blessing neither to the pyrotechnists, nor to the chemists, nor to the torpedo-makers, but rather to the impossibility of finding a general of sufficient genius to handle armies of several millions of men or enough provisions to feed them. With the complex organization of future societies and the exigencies of service obligatory upon all, a great war, the breaking out of which would suspend social life in a day, will have become morally and *materially* impossible.

WATER-SUPPLIES FOR CITIES AND TOWNS.

By Floyd Davis, E. M., Ph. D.

SOME cities and many small towns derive their entire water-supply from cisterns and wells. These sources command our attention, especially on account of the possible excellence of the former, and the disease that is often produced by the latter, through sewage contamination. Nearly all wells in the northern Mississippi valley are situated in drift gravel, and necessarily receive a portion of their water from surface drainage. Such wells, generally, should not be used in cities and towns, for it is much easier to guard against impurities in one general water-supply than against the ill-effects that may arise from many hundred or thousand polluted wells. Even under favorable circumstances cisterns and wells do not furnish the conveniences and comforts of modern civilization, or proper protection against fire. Water-supply systems only can do this; and the popular clamor for public waterworks, supplying an abundance of pure water, is one of the most important sanitary and engineering problems with which municipal authorities have to contend; and many cities and even small towns are now provided with them.

Aside from all sentiment and duty, the importance of pure water may be considered from a pecuniary standpoint. All sanitarians agree that a majority of typhoid-fever cases come from polluted water, while some eminent authorities claim that the disease is transmitted only by this agent. A conservative estimate of the value of an average individual to the State is at least $1000, so when we consider that about 40,000 persons die annually in the United States from this disease, a loss of more than $40,000,000 to the Nation is clearly shown. Besides, there are about 400,000 cases of this disease each year in our country which costs the people many million dollars more. Add to this the expense attached to other diseases that are transmitted by impure water and the estimate will be swelled to enormous proportions. Every city and town using impure water should consider these facts, and hasten to supply its citizens with pure water from public works.

The urgent demands for such works are shown by the large number of them recently constructed. Over half the waterworks

in New England have been erected within the last eight years, while about 30 per cent. of them have been built within three years. Nearly all the waterworks of the smaller western cities and towns have been constructed since 1880. While the earlier works were built only for large cities and supplied only a small proportion of the people with water, it is very gratifying to know that many towns in the West of less than one thousand inhabitants have waterworks, and a large proportion of our people drink pure water.

The cost of constructing waterworks should be no barrier against them, even in small towns, for under proper management the revenue from water-taxes will always pay a good rate of interest on the money invested. The recently-constructed works for the town of Humboldt, Iowa—completed January 1, 1891—will illustrate the necessary expense for one of its kind. Humboldt has a population of about one thousand, and the amount of water used in it is 16,000 gallons daily ; but the railway company will be supplied eventually with some 25,000 gallons more. The water is taken from two springs on the bank of the Des Moines river, and is conveyed to a well sunk two feet below the river, so as to use river water when necessary in case of fire. To furnish the required pressure the water is pumped from this well into a reservoir of 112,000 gallons capacity, situated in the bluff west of the town, and from this the water is distributed through mains which are now 165 rods long. The cost of this plant, including boiler-house, engine, pumps, mains, valves, hydrants, trenching and laying pipe, reservoir, conduits, well- and spring-houses, engineering and contingencies was about $8000. The works would be a good investment for Humboldt had it cost several thousand dollars more.

Waterworks using spring and ground water that requires no filtering are the cheapest and generally the best systems that can be used. When the required pressure can be secured directly from springs, or from reservoirs below them, the necessary expense is comparatively small ; while purifying plants suitable for treating impure river water are generally too expensive for small towns, and the expense of purification in small plants is also too frequently unsatisfactory.

There is certainly no sanitary or industrial enterprise that insures a more rapid and solid growth of a city than an abundant public supply of thoroughly clarified and wholesome water, suitable for

most manufacturing and all domestic purposes, and furnishing ample protection against fire. Thus we find progressive cities and towns are generally provided with excellent waterworks that derive their supply from the ground reservoirs, springs, rivers, lakes and ponds. As the water from some of these sources is often hard or impure, the problem of purification is sometimes well-nigh insurmountable; but by the use of chemical agents, efficient filtering systems and aerating plants, satisfactory results are generally achieved. Even where excellent waterworks are established, some cisterns or wells must be used in localities where distributing mains cannot be laid economically. The various sources of water-supply for cities and towns may, therefore, be considered briefly in the order which follows.

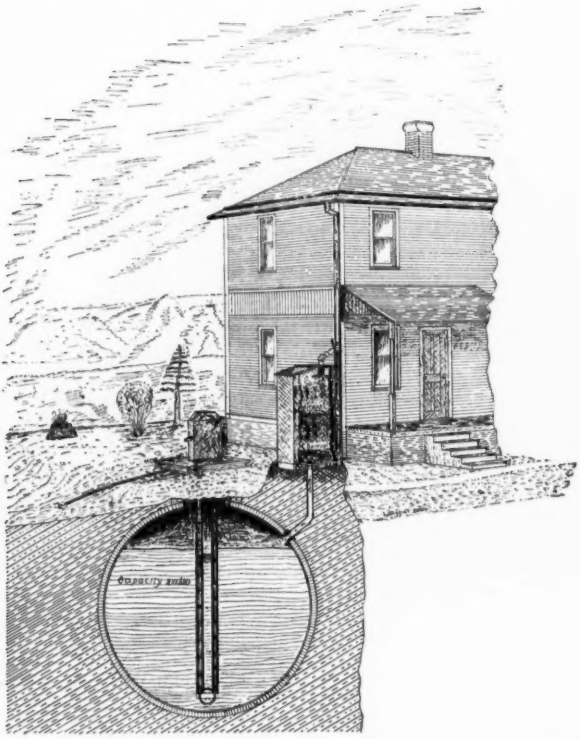
Properly-filtered rain-water is usually as good as any deep-well water, and is superior to that from surface wells in populous districts, for it is always free from sewage and is soft and suitable for bathing and laundry use. This is the water that generally should be used in the cities and towns having no waterworks; and its use in such will become more imperative year after year as filth accumulates in the soil and renders surface ground water more dangerous. Decaying organic and other suspended matter, like germs, are washed from the air by the rains, being nearly all removed at the beginning of a storm, and the rain that falls thereafter is quite nearly pure.

Rain-water should be stored in deep, well-constructed cisterns, so that no contaminated water can drain into them. From a large number of analyses of cistern waters we have never found one unwholesome, except where the cistern was improperly kept, or where there was leakage of dirty ground water through broken walls. Filtering partitions should never be used in cisterns, for they soon become filled with decaying organic matter, act as germ-propagating centers, and thus do more to contaminate than to purify water. Cisterns for domestic use should be filled only during the fall or winter season, when rains are abundant, and then only after the atmosphere and collecting surfaces have been thoroughly cleansed.

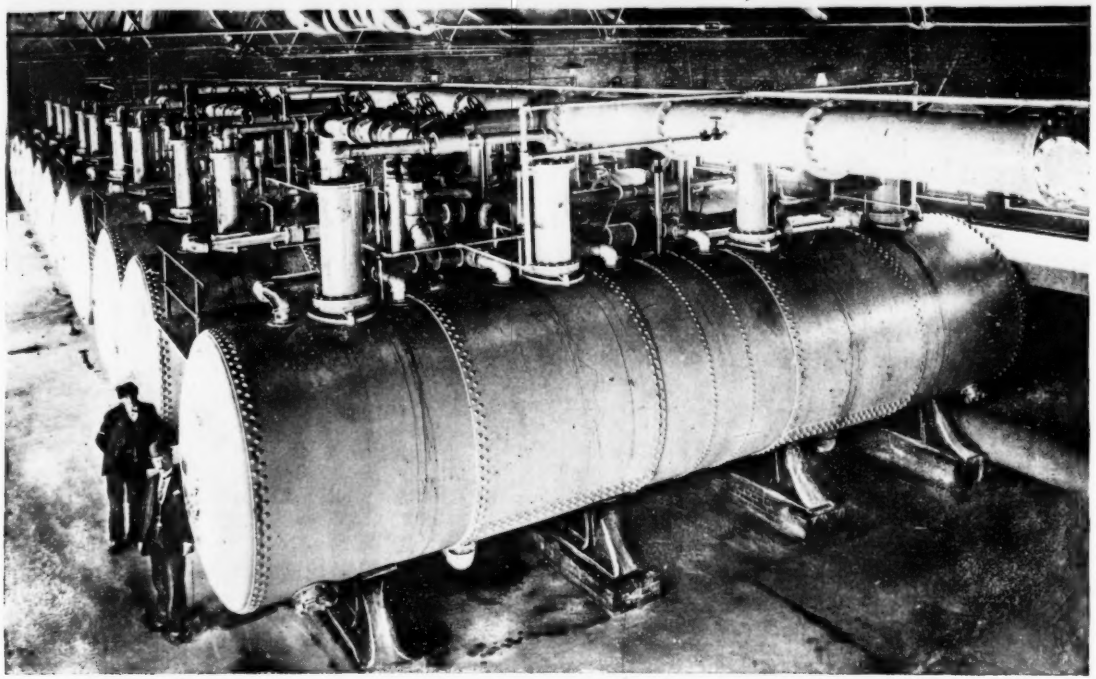
A properly constructed and well-kept filter should be connected with every cistern used for storing drinking water. The best of these with which we are acquainted has two compartments, one above the other. The upper one receives the water as it flows from the roof and is about three feet in depth, having coarse pebbles at the bottom, gradually changing to fine sand at the top.

The lower compartment receives the water from the sand filter, and contains well-burnt, aerated, pulverized charcoal, from which the water passes to the cistern. Both filters should be frequently removed and cleansed, and the charcoal reburnt. Under proper management the upper filter removes nearly all of the suspended matter, and the lower one oxidizes much of the soluble organic matter, and absorbs the foul gases.

Cistern water, like any other stored drinking water, should be thoroughly aerated, or it probably will acquire an unpleasant odor. It is doubtful if any method of removing water from cisterns is superior to chain-pumps, on account of the thorough agitation and aeration which they give. Rain-water, when properly filtered,



A GOOD CISTERN FILTER.



AMERICAN FILTERS AT DAVENPORT, IOWA.
The Largest and Most Expensive Pressure Plant in the World.

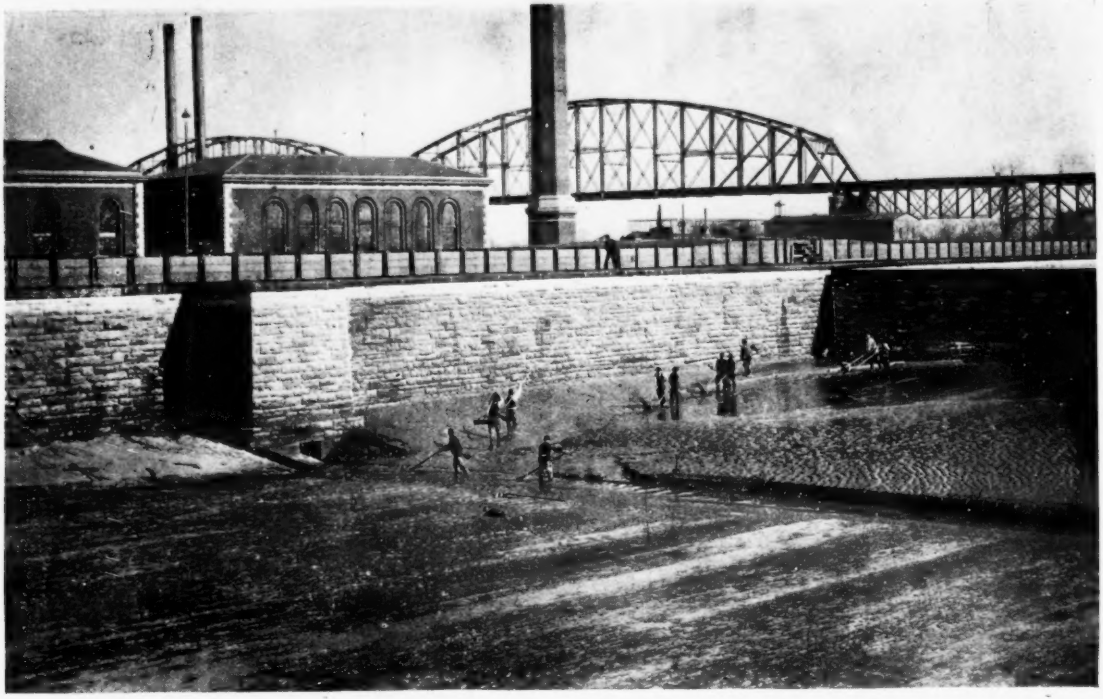
ST. LOUIS SETTLING BASINS, SHOWING METHOD OF FILLING.

stored and aerated, has no odor, but has a flat, characteristic taste, due to the absence of carbonic acid and alkaline salts. Such water usually gives excellent satisfaction for all domestic purposes, after taste for it is acquired, and no ill-effects will arise from its use.

Shallow wells should never be used in cities and towns, for reasons given in the December issue of this magazine.* Deep wells, however, often furnish an excellent drinking water, because it is taken from beneath the agencies of contamination. To prevent an influx of filthy soil water these wells are sometimes laid up in hydraulic cement from the water line; when they are bricked up in the ordinary manner no protection is offered against admission of surface soil water, and they are no better than surface wells. Driven wells are generally much superior to open ones, for the latter are liable to accumulate dust on the water, absorb foul gases from a stagnant atmosphere, and allow small animals and insects to pass in. Wells ought not to be situated in cellars on account of their stagnant, impure air.

The wooden curbing around the ordinary well and the wooden pump sometimes used in it are frequently a source of contamination, and they afford lodging for myriads of insects that find their way into the water. Whenever open wells are used some process of agitation and aeration is desirable, to oxidize the organic matter

* "Impure Water and Public Health," by Floyd Davis, p. 359.



ST. LOUIS SETTLING BASINS, SHOWING METHOD OF CLEANING.

NATIONAL FILTERS AT CALDWELL, KANSAS.

and keep the water fresh. This is done conveniently by a chain-pump or by the "old oaken bucket." A well should be as far as possible from all privies, barns, stables, cesspools, and other agencies of contamination, and should have a free natural drainage in all directions from it.

Ground water, secured out of range of contamination, is used frequently for city waterworks. In this system, wells are sunk from ten to forty feet deep and are inclosed in iron or cemented walls, to prevent an influx of surface ground water. Filtering galleries and perforated pipes are also frequently used in collecting ground water, and from these it is pumped into the city mains. The wells for a ground water system should usually be located outside and above the city limits, where no impurities can get into them. Ground water is subjected to natural filtration, but as a portion of it may flow from beneath a populous district, it is liable to be impure, and is then like surface-well water. But when it is taken from beneath an impervious stratum that separates it from the surface water, the results are very satisfactory. The water is then similar to that from deep wells in subterranean strata. Artesian water is usually free from contamination, but it is sometimes quite hard.

In seeking a ground water-supply a preliminary examination of the country with reference to drainage and permanence of supply should be made, and the location of wells, galleries or collecting

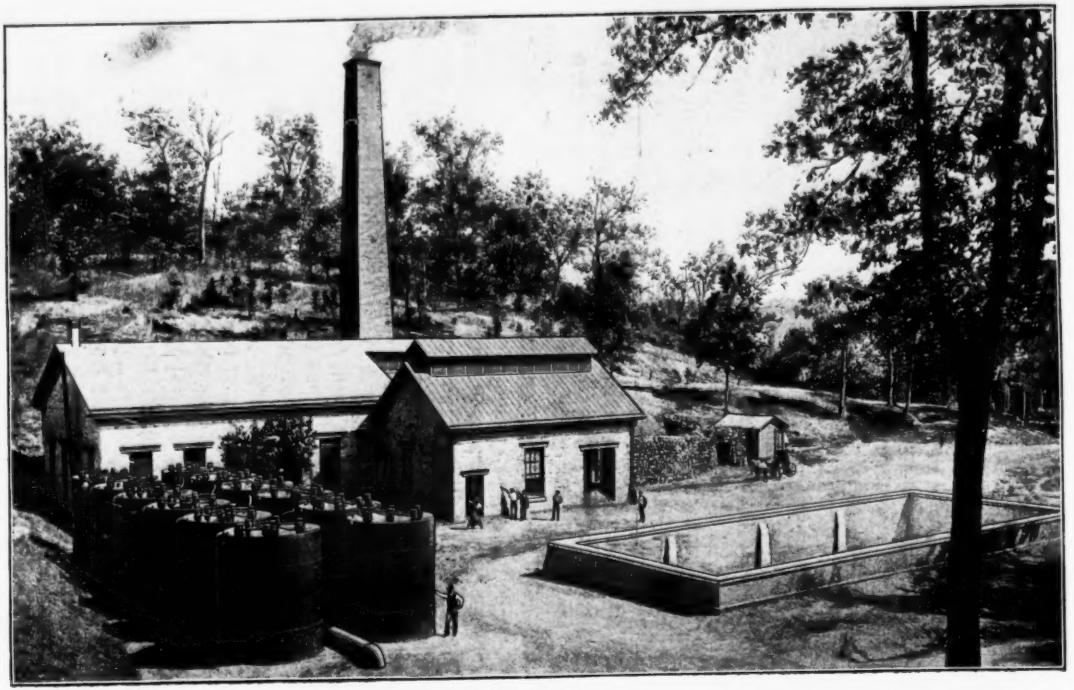
THE DES MOINES ARTESIAN WELL.

pipes should be such that drainage from cities, cemeteries and slaughter-houses will not contaminate the water; neither should they be too near a polluted stream. In considering a source of water-supply too much care cannot be bestowed upon testing the various ground waters, and in considering their possible future pollution. When purity and abundance are scientifically assured, and proper precautions observed in preventing pollution, the excellence of the water may remain constant for years.

The amount of water that can be secured at first from a well is greater generally than that which will follow, and failure of a well is sometimes the result of an overestimate upon the amount of ground water. To furnish an adequate supply, the wells are usually sunk in gravel beds along the banks of rivers or lakes, for these are usually saturated with water; and also in case of fire the larger supply can be used. In some cases the ground water may filter directly through the soil from the river, but it generally is otherwise. The beds of most rivers, like artificial filters, soon become clogged and are impervious to the water, so when the ground water supply is dependent largely upon the river its permanence is very unsatisfactory. The sanitary results are then often unsatisfactory, and it is always unsafe to rely upon the character of the river-water as representing that of the well. In some cases it may be the same, but it generally is quite different.

Properly-selected ground water is often the purest and only sufficiently abundant water that can be used for public works, for when the wells or galleries are sufficiently deep only well-filtered and purified water will be pumped. Nature's processes of purification cannot be surpassed by art, and the ground water system, when properly protected, is, in our judgment, superior to any existing artificial purifying process. Many cities and towns are now considering a ground water-supply and will likely adopt it in their new waterworks. This system will be used more generally as the country becomes more populous and rivers more contaminated with sewage.

Spring-water is generally like water from deep wells, being quite hard and free from decaying organic matter and micro-organisms. These substances are removed by its filtration for long distances through bacterial soil, and by its natural aeration. But soil filtration is no absolute guarantee against zymotic infection, for it is not a safeguard against disease germs. Under ordinary conditions, however, spring-water is at all seasons of the year



THE ATLANTA WATERWORKS.

one of the purest waters that nature gives us, and should generally be used in country houses when it is available. Carbonic acid is washed from the atmosphere and is formed by the decay of organic matter in the soil. This gives a high degree of potability to water and often makes deep-seated ground waters delightful to drink. A perfectly pure spring-water is certainly the best beverage for healthy people. It is so much superior to surface-well waters that many cities, especially in mountainous regions of our great West, have adopted it as a source of public water-supply, and some of the purest drinking-waters from public works that we have examined have come from these regions.

Typhoid fever is rare in cities and towns supplied with spring-water, and the city of Vienna, by bringing the water-supply from springs sixty miles distant, freed herself of much sickness, such as prevailed there when filthy river and surface-well water only was used. Pure spring-water is certainly good for public supplies, and we urge upon all cities and towns contemplating waterworks, that are so situated as to use spring-water, to consider well this most excellent source. The only serious objections that can be offered against it are the elements of hardness and amount of available water.

Manufactories and cities are often located on the banks of rivers, on account of the available water-power, transportation by boats and easy drainage. From these enterprises pollution is added to the water; and rivers are also the natural drains of the country through which they flow. "They are the receptacles of all the waste products of the inhabitants of the district; they receive the contents of sewers, cesspools and privies; the offal of distilleries, slaughter-houses and tanneries, and the refuse of factories. Into them are thrown carcasses of dead animals, as the most expeditious method of burial." The substances undergo decay which produce disturbances when taken into the system, and propagate the germs of disease. Water thus contaminated is a filthy and dangerous beverage, and notwithstanding its natural purification it may never be free of infectious matter. A river that receives much filth in its course is certainly unfit for direct use in waterworks; and it is even doubtful whether any existing process of central purification will render water containing the dejecta of fever patients absolutely safe for drinking. Such water can only be rendered safe by domestic purification. But river water is necessarily used in many waterworks, where it should receive a care-

THE DES MOINES WATERWORKS STAND PIPE.

ful preliminary purification before being admitted into the city mains.

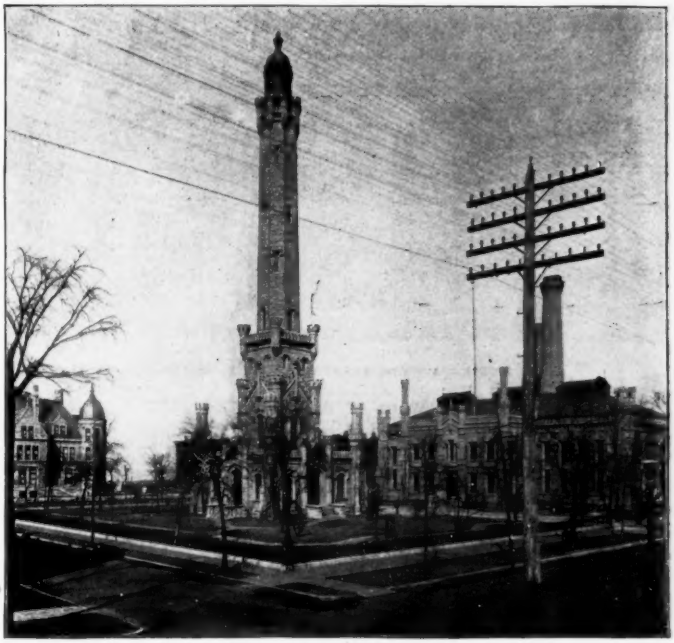
Muddy river water, free from sewage, is sometimes clarified by sedimentation for city supplies. It is here pumped into shallow settling basins and allowed to remain at rest for many hours, when it is drawn off, and at regular intervals the sediment is removed from the basins. As the inorganic matter subsides some of the organic matter and germs are also removed. But when the water contains finely divided particles of clay, the subsidence is too slow to be of much value in purification, and the softer the water the

DES MOINES WATERWORKS—A GROUND WATER SYSTEM.

slower the subsidence. At St. Louis* the sediment of the Mississippi river at certain seasons of the year amounts to 1.8 per cent. by volume of the water, and about 94 per cent. of this is removed in the settling-basins within twenty-four hours, during ordinary stages of the river. But for weeks in the spring no convenient length of time will completely clarify this water, and even during the remainder of the year the water from the city mains is usually clouded with suspended matter, but is so free from infection as to be considered wholesome.

* The new waterworks at St. Louis will take its supply from the Mississippi river a few miles below the mouth of the Missouri, at a place called "Chain of Rocks." Missouri river water will, therefore, be used most of the time, and only a small proportion of the real Mississippi at any time.

Water of the above nature can be clarified satisfactorily by passing it through filter-beds, constructed of gravel and sand. The water-supply of the city of London is purified in this way, and it is claimed that from 95 to 99 per cent. of the impurities are removed from the water. But for contaminated water one of the more modern processes is generally used in this country. In most of these, the water is subjected to some method of coagulating its



THE CHICAGO WATERWORKS.

organic matter. Alum or aluminum sulphate is generally used for this purpose; but in Anderson's system metallic iron is the coagulating agent, and as the water passes through this in the revolving purifiers, nearly all of the germ life is also destroyed. The water is then filtered either through gravity or pressure filters, which remove the coagulating agent and entrapped organic matter and germ life. The filters used in this country are generally constructed so that by reversing the current, using filtered water, the impurities are easily washed from them. So by proper manage-

JEWELL GRAVITY FILTERS AT TERRE HAUTE, INDIANA.

ment, reasonably pure water can be secured from sources that could not otherwise be used. Some of the filtering plants have aerating appliances attached to them, for the purpose of destroying some of the organic matter not removed on the filters.

Lakes are the natural settling basins for rivers and other streams that flow into them, and their waters are not often widely different from their sources of supply. They are less liable, however, to be rendered turbid than streams, and they remain cool during summer. But the water around their borders is sometimes impure from the inflowing polluted streams and sewage of cities; and lake water-supplies, like that of Chicago, has to be taken several miles from the shore, beyond the limits of pollution. To prevent such contamination better methods of sewage disposal must be effected. This is a serious problem now being considered by the ablest engineers.

It is evident from the preceding remarks that no water furnished a city or town from wells or impure streams can be absolutely safe for drinking, unless the infection is removed. This can be done by sanitary filtration, by boiling and by distillation. When

a city is supplied with only doubtfully pure water, no family should be without a private filter. Even the purest natural waters can often be improved by proper filtration, for the suspended substances will be removed and chemical changes often effected by this operation. But any medium suitable for a sanitary filter must have pores not more than one twenty-five thousandth of an inch in diameter, or it will not successfully remove bacteria from water. The filtering media of the best sanitary filters are unglazed porcelain and unsized paper; the former can be cleaned and the latter removed. When the filters are properly cared for the water that passes through them may be perfectly sterilized, and therefore absolutely safe for drinking. The importance of domestic filtration cannot be too strongly urged upon the public, but space permits us merely to mention the matter here.

A water that is suspected of being impure and dangerous can be rendered safe for drinking by being boiled for half an hour. This operation destroys all infectious germs and coagulates all albuminous substances. If such water is then filtered and properly aerated, it will be a safe and delightful beverage. But distilled water is better in many cases, and domestic distilling apparatus can now be secured very cheaply and a wholesome distilled water prepared at little cost. By its use in families afflicted with kidney difficulties we believe that much serious and perhaps often fatal trouble would be avoided, and impure water in these cases would not be a means of transmitting disease.

When distilled water is aerated it is nearly perfect for drinking, for it is wholesome for all classes of drinkers, and especially desirable for those afflicted with renal and bladder diseases. It acts upon the kidneys as a powerful therapeutic agent in the solution and removal of the waste products of the body. Those unaccustomed to it do not realize what an effect such water has on the kidneys; "its effect is better than that of acetates, nitrates, opiates, or alcohol, and for people with a tendency to kidney diseases or dropsy there is no better drug than pure water. Of the thousands of chemical compounds and waste products found in the human system, many require pure water for their solution and elimination; and water so overloaded with salts as average well water is will not work satisfactorily."

THE GOLD-FIELDS OF ECUADOR.

By Russell F. Lord, C. E., E. M.

RECENT surveys of some old Spanish grants among the western Cordilleras, in Ecuador, reveal the existence there of placer-gold to an almost limitless extent, under exceptionally favorable conditions for hydraulic-mining. As a result companies have been formed for extensive mining operations in this district, and the work of providing the requisite machinery is already under way. The writer having finished a professional examination of two of the mining properties a very short time before the date for printing this number of THE ENGINEERING MAGAZINE, on being asked to contribute some account of their resources, finds himself unable within the limit of time afforded to offer more than some extracts from his reports. Nor is it possible here to convey a full idea of the richness of the auriferous gravel and the ease with which, on account of unusual natural conditions, the work of mining may be prosecuted. It may be mentioned, however, that the reports which are here drawn upon have furnished the basis for the decision of the capitalists interested to proceed to the work of mining, while it is equally proper to state that inasmuch as no desire exists to obtain further capital from the public, the representations herein respecting the mines are not to be regarded as an advertisement, but merely as the response of a busy engineer who has never found time for magazine-writing to a request from an editorial friend for some facts about a wonderful new Eldorado.

The mining properties are three in number, known as the Cachavi, Uimbi and Playa de Oro, located near the Colombian frontier and about thirty miles from the Pacific coast. They are situated in contiguous valleys, running from northwest to southeast in the order named, separated by low ranges of hills which are spurs of the Cordilleras. Each valley has its own system of rivers and streams, providing at convenient intervals ample water for all the necessities of hydraulic-mining, and all emptying into the Santiago river, a large stream furnishing facilities for navigation to within a few miles of the mining localities. The examinations made by the writer, as recorded here, relate to the Playa de Oro and Uimbi districts.

Through the courtesy of the government officials of Ecuador the gunboat *Cotopaxi* met our steamer, the *Quito*, at Esmeraldas and received our party and supplies on board. We proceeded up the coast some sixty miles and entered the Rio de Santiago at Limones. While crossing the bar, I noted the soundings; the least depth of water being two-and-one-half fathoms, or fifteen feet, and this continued for only about one hundred yards, when we entered six fathoms, and anchored in front of the town of Limones. The commandant of the *Cotopaxi* told me that at Bolivia, another mouth of the river a short distance from Limones, it was safe for vessels drawing fifteen feet of water; there being eighteen feet of water on the bar.

The *Cotopaxi*, drawing nine feet of water, conveyed us up the magnificent Rio de Santiago eighteen miles to Barbon; the junction of the Cayapas river. Above their junction the Santiago and Cayapas rivers are about equal in size. In the Santiago river the tide backs up to the rapids Como Hacemos one-and-a-half miles below the town of Concepcion, which town is eighteen miles from the point to which the *Cotopaxi* carried us and thirty-six miles from the Pacific Ocean. Leaving the gunboat *Cotopaxi* the next morning we started up the Rio de Santiago in canoes of about five-tons capacity, arriving at Concepcion that day. From Concepcion we continued up the river in smaller canoes twelve miles to the town of Playa de Oro. I have given the foregoing details of our journey as the most brief and practical way of showing the accessibility of this property.

The titles to the Playa de Oro ("shore of gold") estate call for a tract of land about four miles in width easterly and westerly and about fifteen miles in length, extending from the boundary of the Uimbi estate on the north to the Cayapas river on the south.

A very erroneous impression exists as to the climate on the west coast of South America. During my examination of the Playa de Oro property I had occasion to keep a record of the thermometer in connection with the barometer. The range of the thermometer was 72° and 82° F., never exceeding 82°. The atmosphere is always fresh and never oppressive. This is owing to the cold antarctic current, the proximity of the Andes mountains and the immense rapid rivers rushing down from them. At the town of Playa de Oro the Santiago river is about five hundred feet in width and I estimate averages 300,000 miners' inches of 2160 cubic feet each in twenty-four hours, or 7500 cubic feet per second

at an ordinary stage of water. I saw no sickness among the natives. Our whole party enjoyed excellent health during the stay, and as for myself, in my explorations constantly wet through and through in the rapids, and with the fatigue incident to cutting my way over mountains, I enjoyed perfect health every moment. The country cannot help being healthy with these rushing rivers of pure and excellent water for bathing and drinking.

My examination of the auriferous gravels extended over that portion of the property contiguous to the Santiago river. The gravel is exposed along the river; in the "cuts" made by the natives for mining, along the gulches and everywhere that the top soil, about four feet in thickness, has been removed. The thickness of the beds is from fifteen to seventy or eighty feet; I saw but one bank as low as fifteen feet. There are no large boulders, or cemented gravel. The character of the deposit is such that the gold is more evenly distributed through the gravel than usually found. I do not mean that every cubic yard is of equal value; but that the top of the gravel seems to have as much gold as at the bed-rock. The gravel contains a slight amount of clay which prevented the gold from settling to the bed-rock; this clay disintegrates easily and does not interfere in washing out the gold. In one of the "cuts" on the "Medio Mundo" ("half the world") gravel bank at Playa de Oro the gravel is forty-five feet thick, covered with four feet of soil. It is some three hundred yards south of the river with a good grade for the sluices and dump, the bed-rock at the "cut" being about fifty feet above the river. I measured a cubic yard in bank, taken from the bed-rock ten feet up, and had the natives wash it in their crude way by running the water over it. Cleaning up the bed-rock 97½ cents in gold was obtained from the cubic yard. In their way of washing the finer portion of the gold is lost.

I then took several pans of gravel from the top of the bank forty-five feet above the bed-rock and washed it by the native "bateas"—a wooden dish averaging 300 to the cubic yard. The result was $1.67 per cubic yard. The natives do not lose as much gold in the batea as in running it over the bed-rock; still they lose a large portion of the fine gold and only care to save that which they can pick up with their fingers. The only thing that guides them in selecting a place to mine, or, as they call it, make a "cut," is to find a depression in the ground where rain-water can be collected. Going up the river from Playa de Oro the bed-rock shows

from fifteen to fifty feet above the river, affording good dumps. At about three miles from Playa de Oro the bed-rock is one hundred to one hundred and twenty feet above the river on the north side. This is the last cut opened on that side of the river and the gravel is about seventy feet deep. Sampling the cut gave 83½ cents per cubic yard. The high bed-rock continues on the north side, and commencing on the south side at Angostura Cut, one quarter of a mile above, continues through the property both sides of the river. I took samples from a number of cuts and the average was $1.03 per cubic yard, for all samples taken on the property. If it was only 10 cents per cubic yard, the profits of hydraulic mining would be simply enormous—as it is well known that under favorable conditions gravel can be washed at 3 cents per cubic yard. The natives say the gravel is equally as thick and rich all over the property, embracing some sixty square meters. We know it is the same general character near the southern boundary this property on the Cayapas river, fifteen miles from the northern boundary. Mr. Frank S. Ketchum, E. M., estimates the value of the gravel on that portion of the property examined by him, lying along the Santiago river, say one-fifth of the property, taking the average at 40 to 45 cents per cubic yard, at $159,800,000. My principal object in visiting the property was to select a point to commence mining operations and estimate for the necessary plant. For general details of the property I refer to the report of Mr. F. S. Ketchum, mining engineer. We have here extraordinary facilities for placer-mining; an immense amount of rich gravel easily washed; good grades for the sluices; high dumps and a soft bed-rock of marine formation, and practically an unlimited supply of water.

Having ascended the Rio de Santiago to a point which is marked on the map 460 feet elevation above the sea and the highest point ever reached by canoe, I found the immense river here boiling and rushing down a cañon not more than sixty to eighty feet wide with walls more than one hundred and fifty feet in height. It being impossible to ascend further by the river we came back about one-quarter or a mile to the Quebrada Agucita* and camped. The next day we commenced to cut our way up and across the country.

My exploration developed unknown Falls, above El Salto, bringing seven hundred feet elevation some three miles nearer the gravel than estimated. This wild river, entering the Santiago at

* The gorge Agucita.

El Salto (the jump or fall) was christened on February 21, 1892, "Rio Francklyn." From above Lord's Falls, seven hundred and five feet elevation, a canal would carry the water around the mountains to Quebrada Agucita, on the Santiago river, in five-eighths of a mile. But the Francklyn river goes up so rapidly that a canal* less than one mile can be taken out and carried across the ridge on the line of my survey, arriving at the same Quebrada Agucita but on the summit of the mountain with 100 feet more elevation—*i. e.*, 800 feet above the sea. The elevation at Santos Quinones, two-and-one-half miles distant, is 350 feet at the river and about 480 feet on the bed-rock, making our head of water 320 feet above the bed-rock and two-and-one-half miles distant. The elevation at Playa de Oro, three-and-one-half miles distant is 250 feet above sea-level and the bed-rock at the Medio Mundo about 270 feet. Sailing vessels drawing six feet of water can come from San Francisco to Gage City, a point on the Rio de Santiago about six miles below Concepcion. A cart-road will be constructed to Playa de Oro fourteen miles distant, making but one transfer and fourteen miles cartage from San Francisco to the mines.

Adjoining the Playa de Oro on the north side is the Uimbi estate, commencing on the Rio de Santiago at Concepcion and extending easterly up the Uimbi and Las Juntas rivers to their source. It is four-and-one-half miles wide on a line drawn northerly and southerly through the town of Uimbi and is said to be twelve and fourteen miles easterly and westerly. The town of Uimbi and junction of Las Juntas and Uimbi rivers is about four-and-one-half miles from Concepcion. The junction of the Juntas Tigre river with the Uimbi is four-and-three-quarters miles above Uimbi as the river runs, and three miles in a straight line.

I went by canoe from Concepcion up the Uimbi river to the town of Uimbi, and during my stay up the Rio Juntas to Las Juntas and up the Uimbi to the Junta Tigre and some distance up the latter stream. There is an abundance of water in all these rivers for mining purposes. One-half mile above the town of Uimbi the bed-rock on both sides of the river is fifty feet above the river and at the Quebrada de Adentro it is 100 to 130 feet above the river, affording an inexhaustible dump for hydraulic mining. The river

* The contemplated initial canal will have a capacity of 6000 miners' inches of 2160 cubic feet each in twenty-four hours, the extent of which will be better understood when it is mentioned that a capacity of from 1000 to 3000 inches is considered large for hydraulic-mining in California.

rushes through this cañon 100 to 150 feet wide, until within about one mile of the Junta Tigre, when the river rises rapidly with fall after fall until the bed-rock is not more than thirty feet above the river at the Junta Tigre, which point by the map has an elevation of 460 feet above the sea. The elevation of Uimbi is 150 feet. Above this junction both the Uimbi and Junta Tigre rise very rapidly and all the water and elevation desired can be obtained by taking the water out high up. All along the Uimbi and Las Juntas are the "cuts" or openings for mining made by the natives—and during the time that I was on the property every cut was being worked by the negroes. There seems to be no difference in the value of the gravel in their eyes, as the only thing that guides them in opening up a gravel-bank is to select a point where there is a depression to enable them to collect the rain-water. The gravel is exposed everywhere the top soil, which is from three to four feet in depth, has been removed. It shows everywhere along the banks of the river in the gulches and small streams. The banks are from four to eighteen feet of gravel above the bed-rock ; I would say generally nine feet of gravel. The gold is unusually equally distributed from the bed-rock to the grass roots. Grades of 4 per cent. and upwards can be obtained on the bed rock for the sluices and high dumps into the river everywhere. These rivers are torrents, and there is no fear that the dumps will get clogged. The day I came up from Concepcion, about one-half hour after I landed, I saw the river had risen ten to eleven feet in that time. Always, on the river in this cañon, when the natives hear it thunder or see a black cloud towards the mountains, they at once seek a landing place and are careful not to get caught in the cañon.

For general details as to the property, the gravel, amount and richness—60 to 65 cents and upwards per cubic yard—I refer to the reports of Mr. Clarence E. Dougherty, C. E., M. E., and Mr. Frank S. Ketchum, M. E. The value put on the gravel and the estimated amount—43,000,090 cubic yards, one-eighth of the Uimbi property immediately available—is a fair estimate.

The people inhabiting these estates are pure negroes descendants of the old slaves. There is no admixture of any other race, white or Indian ; all are black, and it is a sacred tenet with them to keep their race pure. They are governed by their old men, and have the greatest respect for their elders, always asking a blessing whenever and wherever they meet them. There are no roads, mules or horses in the country, their mode of travel being by canoe, on the

various rivers, and all, both women and men, are very dextrous in handling their canoes in the rapids. They do no work whatever, except to build their canoes and houses and wash gold whenever they need anything from the trading-port Conception. Their food consists mainly of plantains.

The titles to these immense properties, together with the Cachavi estate, adjoining the Uimbi on the north and fully as large, of the same general character as the Playa de Oro and Uimbi, having been reported upon by F. S. Ketchum, E. M., and Clarence E. Dougherty, C. E., M. E., are old Spanish grants—property held in fee simple with mining rights attached which have been recognized by the Republic since the Colonial period and have been passed upon by the leading legal talent of Ecuador and the United States. The parties for the past two years have been quietly at work making the surveys and securing titles. Everything being complete, there is no longer any object in keeping their worth from the world, and the details of the surveys are now for the first time made public.

ELECTRICITY.

Conducted by Franklin L. Pope.

THERE are at least three errors or misconceptions in reference to the telephone business, which have become so firmly rooted in the popular mind that it seems scarcely worth while to attempt to controvert them. The first is, that the exchange service in the principal cities will be greatly cheapened upon the expiration of what the newspapers call the "monopoly patents." As Mr. Herbert Laws Webb pointed out in an article in this magazine for March, the amount paid by each individual subscriber by way of royalties on his patented telephone is so small a fraction of the aggregate cost of service as to be hardly worthy of consideration. The second misconception is, that the larger the city and the more subscribers an exchange has, the less ought to be the rate charged each subscriber for service, whereas it is well known that the reverse is more nearly the truth. The explanation of this seeming anomaly is found in the peculiar character of the service. One of the largest items in the expense account of an exchange system is the labor of employés at the central station. The actual cost of performing the service is nearly in proportion to the number of connections made per diem, and this for obvious reason, increases in a far more rapid ratio than the number of subscribers. In some instances, the addition of a single subscriber, such for example as a commercial agency, or an express office, may throw an enormous increase of work upon the central station operators without increasing the revenue more than the amount of one single subscription. The cost of installing and maintaining the switching apparatus at the central station also increases nearly in proportion to the square of the number of subscribers, and this item alone, in a large exchange, mounts up to an enormous sum.

Two or three years ago, when the newspapers and the public were applauding without stint the "energetic" measures of the Mayor of New York City in summarily chopping down and destroying the overhead lines in the streets, thus entailing an enormous, and for the greater part, wholly uncalled for and unnecessary burden of expense upon the electric companies doing business in the metropolis, we had occasion to remark more than once that these same citizens would not find it so amusing when they came to pay the bills for this wanton destruction. They have now got a foretaste of what is coming, in the recent increase of telephone rentals, a step which has been rendered imperative by the financial burdens imposed upon the electric companies by the subway craze. While we have never questioned the abstract desirability, and even necessity, of placing the electric wires underground as rapidly as it could be done with reasonable regard to the technical requirements of the case, we cannot commend the policy of compelling a work to be done in two or three years which, as the results will ultimately show, might better have been extended over twenty, especially in view of the fact that one consequence of that policy will be to forestall the possibility of supplying electric service of any kind in the metropolis at a reasonable price for a generation to come.

The third misconception is, that a large number of improvements in the art of telephony of inestimable practical value have been invented, the enjoyment of which by the public is prevented by a sort of a conspiracy on the part of the courts to suppress them, one and all, as infringements upon Bell's patents. While this is no doubt honestly believed by some hundreds, or perhaps thousands of sanguine inventors in this much-worked field, the fact that none of these alleged improvements have made any particular stir in the neighboring Dominion, where the Bell patents are no longer in force, points to a different con-

clusion. It would be rash to assert that no improvement is possible, but we doubt if any very important ones have met with unmerited neglect and suppression.

THE longest distance to which electric power is actually transmitted for electric lighting in the United States is about thirteen miles. A plant of severalthous and incandescent lamps in Portland, Oregon, is supplied with current from generators at the falls of the Williamette river. An alternating current of 5000 volts potential is employed. Quite recently it is reported that the Westinghouse Company of Pittsburgh, who designed and erected the Portland plant, have contracted for another one at Pomona, in Southern California, in which about 1000 horse power is to be conveyed fifteen miles at a pressure of 10,000 volts. This plant, if successful, and there appears no reason why it should not be will constitute a notable achievement in electrodynamics.

PROFESSOR ELIHU THOMSON considers that it is not commercially practicable, in the present state of knowledge, to make use of currents of large volume for power transmission at a pressure exceeding 2000 volts, and hence that we must look to alternating currents as the only feasible means of transmission at very high potentials. This, in most cases, would involve two sets of transformers, one for raising the potential at the generator end and the other for lowering it at the motor end, but even under these conditions, he thinks that with well designed apparatus the total loss of energy, including generators, motors, line and transformers at full load need not exceed 25 per cent.

In connection with the subject of high potential transmission, the somewhat startling possibility recently suggested by Professor Thomson—in respect to which he remarks that the difficulties of its realization are less than at first appears—that of conveying 130,000 horse power through a conductor of one-twelfth of a square inch cross-section, have strongly directed the attention of electricians to the advantages attending the employment of oil as an insulator for high potential circuits. A recent discussion of the subject has recalled the fact that this method of insulation was originated and to a considerable extent worked out by David E. Hughes, an American electrician long resident in London, shortly after the failure of the first Atlantic cable. The matter lay dormant until a few years ago, when it was reinvented and quite largely introduced by the late David Brooks, of Philadelphia, who laid quite a number of successful oil-insulated cables for telegraph and telephone service both in this country and in Europe. In a recent discussion before the Institution of Electrical Engineers in London, Mr. W. H. Preece, electrician of the Post-Office Telegraphs, remarked that some Brooks cables laid for that department a number of years ago, in South London, had always given excellent results and were still in good condition.

THE Massachusetts Railroad Commissioners have done well to call attention, in their annual report to the Legislature, to the imminent danger arising from the rapid increase in the number of crossings at grade of steam railroads by electric street lines. Under existing conditions, an electric car is much more liable to be stalled at the point where it crosses a steam railroad, than anywhere else. It is quite usual to dispense with frogs at these crossings, a circumstance which not only increases the liability of derailment of the street-car, but produces a sudden series of jolts which often unships the trolley from the overhead wire. In addition to the risk to which its passengers are subjected, the weight and bulk of the modern electric car are so great that a fast train coming in collision with it would run no small chance of a disastrous wreck. One solution of the problem which suggests itself as being applicable in many instances, is to carry the street railway under the steam railroad by a tunnel, the approaches to which might be made much shorter and steeper than would be admissible for the use of ordinary vehicles. The employment of stout gates interlocked

with semaphore signals situated at a sufficient distance on each side of the crossing would also afford a very effectual means of protection. Considering the very great number of these crossings in the country, the small number of accidents hitherto reported is certainly surprising. But it ought never to be forgotten that "what may happen, will happen," and that when a disaster of this kind does occur, it may be of an appalling character.

MR. PHILLIPS'S System of Telegraphic Shorthand, of which some account was given in the department of Electricity in our April magazine, while capable of largely increasing the carrying capacity of a telegraph line for certain classes of business, is not, in a strict sense, an improvement in telegraphy at all. This suggests the reflection that the radical improvements which been introduced in the art of commercial telegraphy in this country, since the date of the completion of the first public line, nearly half a century ago, are so few in number that they can almost be counted on the fingers of one hand. Each of them, moreover, furnishes a forcible illustration of the saying that "necessity is the mother of invention"—a proverb, by the way, which in these days is by no means as universally true as it used to be. The first obstruction of a really serious nature to the extension of the telegraph arose from the lack of means for crossing broad, navigable bodies of water, an obstacle which was soon surmounted by the invention, by Dr. James J. Craven, in 1847, of the gutta-percha insulated cable, by means of which the Hudson river was successfully crossed the following year. The next radical improvement in the art was the interpretation of communications by the sound of the instrument, instead of the permanently recorded signs, an innovation first made by the operators, and by them persisted in, in spite of the bitter opposition of Professor Morse and all the directors and managers of the lines, but which has proved to be from a commercial point of view of incalculable value. The defective condition of the insulation of the conductors rendering it practically impossible to transmit intelligence over two or three hundred miles in wet weather, necessitated the invention of the automatic closed-circuit repeater, by which two or more lines of limited length could be united in a series, and operated as one. This was first accomplished in a practical way by Moses G. Farmer, in 1855. The next difficulty arose from the excessive multiplication of wires between the principal commercial centers, due to the vast increase of business in the years following the close of the rebellion. This problem was solved in part by the invention, in 1871, by Joseph B. Stearns, of the electrostatic compensator, which made the hitherto almost useless German invention of the duplex telegraph, available for doubling the working capacity of every wire to which it could be applied, a device which the inventor subsequently applied, with equal success, to the transatlantic cable lines. The capacity of each duplex line was once more nearly doubled by the "quadruplex" system of operation, invented by Thomas A. Edison, and applied to the Western Union lines in 1874. It was soon found, however, that the application of these improvements, while largely avoiding the multiplication of wires and attendant inconveniences, so far from proportionately diminishing the number of batteries required, served rather to increase it, so that the amount of space required to accommodate these necessary adjuncts, especially in a great telegraphic center like New York, became a most serious tax upon the resources of the establishment. At this juncture, Stephen D. Field, in 1879, successfully adopted the dynamo-electric machine, driven by steam-power, to the requirements of the telegraphic service, an improvement which soon abolished the voltaic cell in all the larger stations. In this necessarily brief outline of the progress of improvement in commercial telegraphy, many inventions have been passed over, which although of great merit, failed to materially influence the present state of the art, such among others as the type-printing machine of House, and the automatic apparatus of Bain.

Much reproach has been heaped upon

the management of the telegraphic service of the United States for its conservatism, and its alleged unwillingness to consider and adopt new methods which are claimed to be improvements. In respect to the department of engineering and construction there is no doubt abundant scope for criticism of this character, but as regards methods and processes of telegraphy, it is to say the least, very doubtful if it can be shown that any improvement of permanent commercial value has failed to receive the consideration to which it is entitled.

IT is to be feared that the citizens of New Jersey have small reason to congratulate themselves upon the passage, by the late unlamented Legislature, of a law creating an Electric-Subway Commission. The act provides that "no telegraph, telephone, electric-light, electric wire or cable, shall hereafter be constructed along or over any street in any city of this State," unless authorized by the Board. For the purposes of the act the Board is given absolute control of the streets in all the cities of the State, and all the powers of the local authorities are by express provision, made subordinate to the powers thus granted. All subways must furnish free accommodation for municipal wires. Whenever the Commissioners deem it necessary for the public safety they may compel any and all wires in any city to be put underground. The power of the Commissioners is made absolute and there is no appeal from their fiat. While the professed object of the act is to promote "the public comfort and safety," one of its advocates was overheard to remark while the bill was upon its passage, that its real intention was "to make Jay Gould squeal." The appointment of three of the most notorious machine politicians in the State as Commissioners would seem to lend an air of great probability to the opinion of the somewhat too candid assemblyman. All the expenses of burying the wires, and of the Commisson itself, including their salaries and the salaries of the unlimited number of official assistants which they have full power to appoint, are to be paid by the electric companies, and by them, as a necessary consequence, will be charged over to the consumers. As this will undoubtedly furnish an all-sufficient pretext for further legislation next year, limiting the maximum charge for electric service of all kinds, it will be seen that every encouragement is offered for capitalists to invest hereafter in electric enterprises outside of New Jersey, rather than within its limits.

A WELL-KNOWN author put into the mouth of one of his no less well-known characters, the observation that "for ways that are dark, and for tricks that are vain, the heathen Chinee is peculiar; and the same I am free to maintain." We are reminded of the felicity of this characterization by the circumstance that in a consignment of $60,000 in gold double-eagles, recently received from California by a bank in New York, there were found no less than twenty light-weight coins, all bearing dates of 1891. While the coins were apparently bright and new, an examination with the lens revealed the fact that the face of the coin was covered with infinitesimal pores, demonstrating that about a dollar's worth of gold had been neatly abstracted from each coin, by a simple and ingenious process of electrolysis, in which our Mongolian friends are said to have become expert practitioners. As the law can only reach cases in which this operation can be proven to have been performed wtih fraudulent intent, it would apparently be somewhat difficult to secure the indictment of one of these astute electricians, even if he were detected in the very act.

SOME of our rising young journalists are finding food for amusement in a bill recently introduced by Senator Peffer, of Kansas, providing for the establishment of an experimental station for the purpose of determining if electricity can be profitably used and applied as a motive power in the propulsion of farm machinery. Now we would like to place ourselves on record with the opinion, that if Congress would make as liberal an appropriation for this

purpose as it did for certain idiotic experiments in "rain-making" not long ago, which served to make that august body the laughing stock of the civilized world, and the business could be put in charge of some such intelligent and technically-trained electrical engineers as those, for example, who have within a few years revolutionized our methods of municipal transportation, the ultimate result would not be one whit less valuable to the people of the United States, than that of the historic appropriation of $30,000 with which Morse's experimental telegraph line was built from Washington to Baltimore half a century ago. Of course, if the appropriation is made, the chances are that it will be squandered or stolen outright by some of the electrical fakirs who are always on the lookout for such opportunities. Nevertheless we believe in Senator Peffer's idea, and do not hesitate to predict that the day is not distant when the entire labor of preparing and tilling the ground, as well as that of seeding, harvesting, threshing, and transporting the crops to the nearest railway station, wherever done on a large scale, will be performed by electric motors, at a cost as much below the cost of animal-power as the latter has proved to be below the cost of manual labor. The emancipation of the car-horse will be followed at no distant day by the emancipation of the farm-horse, and the results of the substitution, in the purely agricultural districts of our country, will constitute an industrial revolution of almost inconceivable magnitude.

ACCORDING to a computation recently published in the Philadelphia *Stockholder*, the percentage of net dividends returned to the stockholders of street railways in the United States is almost exactly three times as great as that of steam railways. As a general thing, the former class of enterprises have been owned hitherto by local capital. This is no doubt one great reason why they have paid so well; they have been managed under the close supervision of the persons whose money has been invested in them. Signs are not wanting that Wall Street will presently interest itself deeply in this class of investments, and in that case the lapse of a few years may tell a very different story.

While it is true that the propulsion of street-railway cars by electricity, may, after five years' experience be pronounced a success from the point of view of public accommodation and convenience, it must nevertheless be admitted that from the street-railway manager's standpoint this success cannot truthfully be regarded as an unqualified one. While electric power has unquestionably demonstrated itself to be an advance, not merely upon the use of animals, but upon the use of any other power whatsoever which has been proposed for the purpose, its practical application has been accompanied by many serious drawbacks. An individual who had just emerged from a protracted litigation once remarked that the only property the lawyers had left him was his post-office address, and it has been said with equal truth that in the conversion of a horse-railroad into an electric line, oftentimes the sole item remaining of the original property is the franchise. The first electric motors were found to be far too light for the work they were required to do; when these were replaced by heavier ones the original cars proved too weak to stand the strain; then the new cars were so heavy as to be ruinous to the track, and so it was necessary to completely reconstruct that, and so on. For the first year or two the cost of repairs and maintenance of motors, and the losses incurred by breakdowns, constituted a formidable item, but this having been largely overcome by increasing the strength and weight of the motor machinery and the adoption of the so-called gearless design, the trouble has broken out afresh in another place—this time in the track. The destructive effect upon the rails of some of the methods of mounting motors now most in vogue is little short of appalling. It seems to us very clear that there must ultimately be a radical departure, in many important respects, from these admittedly defective methods, before the street-railway problem can be considered to be completely solved. The situation, while not discouraging, is nevertheless one which offers a wide scope

for the scientific application of common-sense, and the sooner it is done the better it will be for all parties concerned.

THE figures given in the annual report of the American Bell Telephone Company show a steady and profitable increase in the business which must be highly gratifying to the stockholders. There are now 788 exchanges; 180,139 miles of wire, of which 70,334 is underground; and 512,407 instruments under rental. The estimated daily number of exchange connections is 1,584,712. The extension of the long-distance system, under the auspices of the American Telephone and Telegraph Company, which amounted during the year to 463 miles of poles and 4942 miles of wire, together with the continued growth of the "extra-territorial lines," which now embrace no less than 114,288 miles of wire, seems to us very significant of the future intentions of the able administrators of this system. A little reflection will show that the long-distance conversational system *per se*, is scarcely likely to prove an overwhelmingly profitable undertaking at the prices charged. Take for instance the 500-mile line from New York to Buffalo, on which the rate for five minutes conversation varies from $4 for Buffalo to 75 cents for Poughkeepsie; say an average of $2. Taking the time spent in calling and getting into communication into account, if this circuit should achieve a gross income of $50 per diem we should say it would be doing remarkably well, considering that the work must be done during six hours of the business day. If the two well-built copper line-wires which constitute the metallic circuit on which this long-distance talk is done were set to transmitting messages by the Morse quadruplex system, they could take care of 300 messages per hour each, or 3600 in 6 hours, which at 25 cents each would bring in $90. For this, and other reasons which we need not now particularize, we shall be surprised if the lapse of a very few years does not witness the metamorphosis of the American Telephone and Telegraph Company into the Ditto Telegraph and Telephone Company. If the prestige of a name counts for anything, the future prospects of this enterprise are not to be underrated.

THE British House of Commons, by a vote of 205 to 147, has decided not to place the working of the telephone system in the hands of the post-office authorities. The Chancellor of the Exchequer said that he was not prepared to accept in an indefinite degree the constant placing of new duties upon the State. He remembered, too, the purchase of the telegraphs and shuddered at the enormous price the Government had to pay for them. He thought the wiser plan would be for the Government to take charge of the trunk lines, leaving to the localities the working of the local exchanges. He was somewhat fearful of the effect of the telephone on the telegraph revenue, but stated that the Government had concluded that financial considerations ought not to prevail against the extension of a system which was considered by the public to be a convenience. The expiration of the telephone patent in Great Britain leaves the local companies a field for free competition under governmental supervision. During the debate, it was stated that 42,000 telephonic messages had been exchanged between Manchester and Liverpool in one day.

THE applications for space in the department of electricity at the World's Fair indicate that the demand is likely to be vastly in excess of the amount of room available. It is estimated by the Committee on Grounds and Buildings of the World's Fair that between 5000 and 6000 arc lights will be required for the proper illumination of the exhibition. The Thomson-Houston Company are to furnish 3500 of these, and the remainder will be supplied by other concerns. The price to be paid is said to be $20 per lamp. There will also be required at least 1000 to 1500 horse-power of electric motors. Fuel oil is to be used in operating the plant instead of coal, and it is estimated that two hundred thousand barrels of this will be required.

MECHANICS

Conducted by Frederic R. Hutton.

THE field of literature offers at least two helpful similes to the man of technical instincts and experience who fancies himself called to a few words of salutation. The earlier of these compares a person undertaking new responsibilities to a new hand at the bellows. This simile conveys the notion that a new and fresh energy comes to stimulate and enkindle that to which it is directed. In this view, to increase a warmth of interest and to enkindle an enthusiasm may well be one of the objects which the new hand should set before him. The result is certainly worth an earnest effort. If it be possible by the method of treatment to elicit discussion and the presentation of views in opposition to his opinions, the new hand may well congratulate himself upon interesting that proportion of the reading public which dearly loves a fight. That clever writer certainly well understood human nature who described the skillful wooing of a spirited maiden by suggesting that the wooer left at the end of his visit several interesting quarrels which required a visit in the near future to adjust. The simile is also helpful upon its negative as well as its positive side. No successful labor of a new hand is to be expected from "blowing" alone, nor will the desired interest be enkindled by wind only.

The other simile, perhaps more helpful and useful, attaches itself to the thought of a new hand upon the throttle. The mind reproduces an instantaneous impression of a rushing locomotive engine and a wide-awake, self-contained, quiet man with long gaze, by whose lightest touch the forces of his mighty organism are at once stimulated and controlled. There is implied in the consideration of this parallel the fact that the forces under the control of the throttle upon which rests a new hand are mightier than its owner. He who undertakes to present a review and summary of the progress and movements in mechanics is dealing with considerations of mighty moment in the progress of this rapidly-moving century. Mechanical engineering underlies, either directly or indirectly, so large a part of the life of to-day, especially in the cities, that every one must feel the importance of his relations to this department of science, and appreciate the value of a correct understanding of these relations. It is therefore, becoming that the new duties should be assumed with fitting modesty, in view of their magnitude and importance. In the second place, the forces finding their vent under the controlling hand, will only accomplish their result with safety and success when they are directed to a certain terminus with a continuity which is essentially unbroken. It will be the object of the new departure to render the work under the editor's hand as helpful as it can be made with his limitations of endowment and experience. The hopes and desires of the new hand will be attained if on the one hand he can arouse and maintain interest and on the other can make his contributions generally helpful.

THE spring of 1892 has been particularly rich in record-breaking performances. The champion of the transatlantic liners is at this writing the *Majestic*, of the White Star Line, from New York to Liverpool, which made its run from Roche's Point to Sandy Hook, a distance of 2865 nautical miles, in five days, twenty hours and twenty-two minutes. The average time during the entire trip was 20.41 miles per hour, and when the total is corrected for a length of eighty-nine miles, a longer route than that taken by the *Teutonic* in its record trip of 1891, by which four hours and twenty-eight minutes are to be sub-

tracted from the gross time, the record stands at five days, fifteen hours and fifty-four minutes. The record for speed upon the railway is borne by engine No. 385 of the Central Railroad of New Jersey, running between New York and Philadelphia, and making a mile in 39¼ seconds, which is a rate of 91.7 miles to the hour, if it could be kept up for that length of time.

The symposium in *Scribner's Magazine* for March on the subject of speed in locomotives has given increasing interest to the possibilities of speed which are suggested in this remarkable performance. The engine referred to was built by the Baldwin locomotive works of Philadelphia, and is of the design which is known as a Veauclain Compound from the name of its designer. The compound locomotive is being developed on nearly every hand, in our own country, but especially so in the railroad shops of Europe. To the non-technical reader it may be said that a compound locomotive is one in which the steam from the boiler enters first a cylinder of relatively small volume in which it does the work of expanding itself and driving the engine, and is from that cylinder exhausted into a second and larger cylinder in which it does additional work of expansion and driving, and is from that second and larger cylinder exhausted into the smoke-stack and goes out in the usual way. The consequence of this steam distribution is that the steam can be made to act more efficiently upon the cranks to produce the rotation of the driving-wheels, and at the same time, when rejected from the engine as exhaust steam, it can be at lower pressure, and will therefore be cooler; or, in other words, the heat imparted from the burning coal, less what is rejected wastefully, is utilized more completely. It becomes also possible to carry the steam pressure to a higher point when it enters the first cylinder, with a corresponding gain of economy and of available power stored in a boiler of given bulk at any one time.

THESE compound locomotives appear in various forms, with two cylinders, three cylinders or four. A favorite English pattern is to have the two cylinders operating at the highest pressure inside of the frames directly under the front end of the boiler and driving the forward pair of the large driving-wheels (or inside-connected) while the low pressure cylinders are outside the frames as in the arrangement which is almost universal in America. In one class of design, the two sets of driving-wheels are not connected together by coupling-rods as is usual in the American engines, so that it is possible for one pair of the drivers to slip if for any reason the weight upon the pairs from any inequality in the track should not be evenly proportioned. This construction involves underneath the engine an axle in which the necessary quartering cranks shall be formed by forging, and the difficulty of access and of inspection of the engine's mechanism in the contracted space under the boiler is a feature to which the American mechanic has not given his cordial approval. The Veauclain design puts a high and low pressure cylinder on each side of the engine and outside of the frames, one on top of the other. The two piston-rods attach themselves to the sliding crosshead, on the top and bottom of it, and from the pin to this crosshead the ordinary connections usual in all engines pass to the two or more driving wheels in the customary manner. The engine therefore attains the advantages in the use of steam which attach themselves to the principles of compounding, and avoids a number of the disadvantages which attach to the other designs which depart more directly from the arrangement which long service in this country has indicated as best adapted to our needs.

The engine whose remarkable performance is under discussion has driving wheels six feet, six inches in diameter, and therefore of a circumference a fraction under twenty and one-half feet, so that at this speed the drivers must have revolved 402 revolutions per minute. The cylinders were respectively thirteen and twenty-two inches in diameter with the usual stroke of twenty-four inches. The volume of the two cylinders must therefore have been as one is to three practically, which means

that if the steam were cut off from admission to the high-pressure cylinder after the piston-head had travelled twelve inches or one-half of its stroke, we should have it escaping from the larger cylinder at a pressure of one-sixth of that which it had when it entered the first cylinder; or in round numbers, the same pressure which it would have had had the admission of steam been cut off at four inches of the stroke in the single cylinder engine of the ordinary type. By thus following longer in the first cylinder, the engine becomes correspondingly more powerful by reason of the more efficient crank angle, with the same consumption of steam, less the losses from the increased radiating and conducting surfaces with which the steam is in contact in the two cylinders instead of in one.

By this arrangement of the cylinders also, certain difficulties are avoided in starting the engine which attach themselves to some of the other designs, and which must yet be provided for in order that the engine may work economically when going fast. The steam-pressure of the record engine was 185 pounds, and its weight was 123,800 pounds.

In the speed discussion referred to, three writers whose connection with present railroading is very intimate and creditable, discuss certain aspects of the high speed problem in railroading. The discussion which puts the limit of locomotive speed as determined by the steaming capacity of the locomotive is perhaps open to the criticism that the calculations are based upon the assumption of proportions which recent developments in detail of construction render susceptible of improvement. It must not be overlooked, however, that the necessity imposed upon the locomotive to manufacture its own power while moving at a great velocity and with the space which can be occupied necessarily limited by the width between rails, and the length which is permissible in view of a sinuous track, there is no question that a limit is imposed in this direction. But he who ventures to assign it in view of these last developments must be suffering from an attack of errant predictiveness which may prove dangerous to him if not brought under control. The discussion of one of the other writers puts the limit of speed not upon the locomotive, but upon the facilities which the transportation department of the road intrusted with the handling of trains may be able to furnish in order to secure an unobstructed track for the flying trains. It is conceded that no satisfactory result which would compensate for the outlay involved, would be returned when all trains, freight, mixed, express and passenger, should be driven at the highest limit of speed. If this principle be conceded, the difficulty from high speed is the difficulty of preventing the fast trains from running into others which they may overtake. While, of course, this is eliminated in part by the multiple track system, the trains of each grade having a special line for themselves, this can apply only to a comparatively small number of trunk lines, and will not affect the lines which belong to the rank and file.

In the second place these very high speeds compel that information be given to the engine-men of the condition of the tracks in front of them for very considerable distances; and while the improvement in the electrical and other systems of signals is keeping pace with the increased demand for them, yet it must not be lost sight of that a train running a mile in thirty-six seconds, which is the hundred-miles-an-hour rate, can scarcely be brought to rest with our most reliable brake facilities within a distance much less than 2500 feet under the best possible conditions as to the rails. And in slippery conditions, while the dew is on the track, this limit is much further than that.

It must not be forgotten also that the engine-man has other duties in connection with his running, besides an unintermittent inspection of his line, and the possibility of something happening, while he is moving at the rate of 145 feet per second, and giving but a second's glance away from the line ahead of him at gages, water, injector or lubricator, must not be forgotten in considering the limits of danger which attach to such speeds. It is even now the claim of engine-men that if the transporta-

tion department will give them the iron, they will make the time. And the disturbance of a transportation department from mists and fog when most trains are running at nearly the same speed would become inextricable confusion when the working of trains was complicated by so great a reduction of speed as would occur if the limit is not to be exceeded where recklessness begins when the track is not visible. The grade crossings also must either be done away with, or protected automatically by gates or signals operated from a distance, inasmuch as the train is moving with a velocity which is only one-eighth that of sound itself, and it would be impossible to hear the train much before it was actually at the crossing where the danger to the highway would exist. It scarcely seems fair in this respect to claim that there is at these higher speeds no more danger than at low; while perhaps the train runs more steadily and on a straight and perfect line there may be no less safety, the danger from collision or a broken line is certainly not diminished.

TWO NEW screw ferry-boats have been added to the line across the Hudson river which connects New York City with Hoboken—the *Hamburg* and the *Bremen*. They as sisters and with the *Bergen*, already in commission, are interesting as showing the progress from the old type. The data of the *Bremen* which has been published show that she is 222 feet long over all and 62 feet wide. Her water-line is 218 feet, 6 inches, by 35 feet, and her loaded draft is 11 feet. She has two screws, one at each end, which are alternately in the bow and stern driven from a compound engine with cylinders 20 and 36 inches in diameter and 28-inch stroke. The boilers carry a steam pressure of 125 pounds and the screws make 125 revolutions per minute on an average. She has been able to make fourteen miles an hour on her regular trips and on a continuous run on her trial trip gave twelve-and-a-half miles without difficulty.

The subject of the relative applicability of the screw and paddle-wheel ferry-boats to such service as is exacted for the ferries in and out of New York, is perhaps too large a one for exhaustive treatment here. There are certain considerations, however, which point to the advantages offered by the screw-boat which the paddle-boat does not secure. The first of these is that the finer lines of a steel screw-boat permit a less displacement than that required by a paddle-boat, which is something over 10 per cent. in favor of the screw design. In the second place, in order that the concentrated weight of the engine may be as near central as possible, the paddle-wheels are likely to be a little past the center of the boat; hence when going in one direction, while the effort of the paddles is being exerted, there is a tendency for the boat to bury itself, increasing the immersion and therefore the resistance. The paddle effort also being transferred to the boat above the water-line, produces a tendency to bury the bows for the same reason, going in either direction. In the third place, the screw-boat concentrating its engine and propelling mechanism below the main deck level does away very largely with the central deck-house in the team space, and the paddle-wheel house in the cabins. This adds very much to the attractiveness of the boat and to the impression of size, even if it be not actually so great.

The great weight and living force of the rotating paddle-wheels make it difficult or impossible to reverse the engine at speed; with the screw, however, and the relatively small inertia of the wheel, it is possible to reverse very rapidly, by which the manœuvring power of the boat in a crowded harbor, and in and out of slips, is very much increased.

With the screw engine and its high speed of revolution, it is possible to diminish somewhat the loss due to the condensation in the cylinder which comes from prolonged exposure therein of the steam which is driving the engine. While perhaps recent experiments have shown that the gain from this high rotative speed is over-rated, it is an argument which may fairly be urged for one type as against the other. The inverted vertical engine also when used compound has less clearance

than in the beam engine applied with vertical cylinders, and of course it is usual to consider these clearances as occasions of loss, inasmuch as they must be filled with steam at each stroke.

There has also been considerable thought given to the advantages offered by the screw-boat in a climate such as that of New York, where ice is liable to form in considerable quantities in the slips and in the open water. If the screw were not immersed, there might be difficulties of some consequence from breaking of blades; but where the screw turns under the water continually, only very thick ice, such as recent winters seem to indicate is unusual, would be likely to meet the blades. In the slips, also, the scouring action of the propeller driven close to the bridge before the boat starts exerts a powerful influence to drive out the ice (and silt also) from the slip and leave it clear. The paddle-wheel does not produce this effect. The paddle-wheel also turning partly above the water in cold air becomes very seriously obstructed with ice forming in the house while the wheel is still. This difficulty would not meet the submerged wheel and would seem an argument in its favor.

On the general subject of screw-propulsion versus paddle-propulsion for boats doing freight business, and without reference to the special conditions prevailing in such ferry-boat service, there are several considerations of weight. It is past discussion now that the screw is more efficient as a means of applying power than the paddle-wheel with fixed radial floats. A certain proportion of the effort of the engine in this latter case has to go towards simply lifting the water as it comes up and lifting the boat as it goes down. The result of these two components is the production of the considerable wave which forms a feature of every paddle-boat's wake. With the feathering paddle, however, entering the water and leaving it at such an angle as to produce none of these losses, or only in a diminished degree, the efficiency comes more nearly the same. The beam engine, with its exceeding flexibility in the matter of alignment, permits it to adapt itself to the conditions of a shallow and flexible hull, which would preclude satisfactory working in almost any other type of engine. In a ferry-boat for shallow draft operating in a current across the slips, the hull may be so wrenched sidewise by a shock against the guide-piles that nothing but the beam engine is at all possible. The beam engine also distributing its weight over the hull both lengthwise and crosswise, has again an adaptability for many conditions which should not be overlooked. For light draft also, the paddle-wheel entering but a short distance into the water is much more suitable than the screw projecting a considerable distance under the water-line if completely immersed.

The availability of the compound engine for ferry-boat service must be considered somewhat in respect to the length of the trip. The low-pressure cylinder of the compound engine being a part of the time in connection with the condensing apparatus, is likely to become cool when the engine stands, so as to require a little persuasion and management to get it warmed up to its work. If this persuasion and management must continue during the few minutes of a short trip, the boat is at the other slip before the advantages of the compound engine have occasion to show themselves. It would scarcely seem advisable to put in a compound engine for any run less than a mile, when the single engine would do so nearly as well and give much less trouble.

An opinion is also growing that for service other than running of electric-light installations, the advantages of high rotative speed have been overestimated. High rotative speed is not the same as high piston speed, concerning which no one seriously disputes. But high rotative speed, involving clearances of considerable extent, lubrication which is copious to the limit of wastefulness, and repair and supply accounts in excess of that required by the long stroke engine, may fairly be compelled to show cause why in every case it should be deemed an exponent of real progress in economy and efficiency.

ARCHITECTURE.

Conducted by Barr Ferree.

THE task of chronicling from month to month the progress of architecture implies a responsibility of no slight order. Architecture is not a science or a record of continuous progress and discovery; it is the most variable of arts, the most general, and the least popular. Strange as it may appear, the people who cannot exist without buildings of some kind, whose civilization is dependent largely upon them or is expressed in them, care little for architecture as an art or as the science of construction. For the present we need only concern ourselves with a single resultant from this condition: that current architecture has its backward steps as well as its forward, that it violates, at times, both common-sense and art, and its record of failures is perhaps not less numerous than its records of successes. It is some compensation that both stages form fruitful and improving themes of study, but the task of the chronicler is not made easy nor his responsibility lessened. It is much the fashion, among those who would lead us in architectural opinion, to look upon the art with more or less hopeless eyes. In truth, it is hard not to do so, when some great enterprise, undertaken under favorable auspices, with unlimited means and intelligent supervision, ends disastrously. But this feeling comes from expecting too much, from judging present architecture by past, estimating current difficulties by previous experiences, none of which have anything whatever to do with the matter. So long as we persist in looking at the present through ancient spectacles, just so long will our vision be impaired, and modern architecture will seem to be the wreck of a once glorious and perfected art.

But this is not the way to approach the subject at all. Modern architecture, and especially American architecture, must express modern needs, fulfil modern requirements, solve modern problems. It is a much more serious matter for it not to do so than for it to fail in coming up to some past standard. This it may never do, because the conditions under which it is made are so different from the conditions under which past architecture developed. We must look at the present and the future for guidance in estimating current work, and this outlook is, on the whole, full of hope and earnest effort. Failures may be as many, opportunities may be as neglected as in the past, but viewed for itself and by itself American architecture contains much good which is better brought out than the evil. Current architecture then, needs to be approached in a modern spirit and judged by a modern standard. The good should be noted with the bad, for if the evil is ignored it can never be cured, while if the good be omitted the cure will seem hopeless. A critical spirit is indispensable in recording current architectural work. Progress in construction, mechanical details, the improvement of appliances, the changes in the conditions under which buildings are erected, all are part and parcel of the record of architectural work. With these, however, are the not less important questions of the proper application of architectural principles to current work, the value of the art element, and, above all, the standard of architectural taste in the community. The field is large; it cannot be entered upon rashly nor with haste, nor with full swing to personal predilections. Neither can such a record be impartial. There cannot be two sides to a question of architectural taste; it must be good or it must be bad; it must be right or it must be wrong; there is no half-way station at which the prudent critic may alight and leave his passengers to reach their destination as they please. Taste is, of course, a matter of personal opinion, but architec-

tural standards rest upon facts that may, if rightly understood, be accepted as unalterable.

"IT is somewhat surprising," remarks an architectural paper in speaking of some recent criticisms of Chicago architecture, "that it does not receive severer comment." Such an opinion well illustrates the current popular opinion anent Chicago buildings, an opinion than which there never was a more absurd one. No other class of buildings is to-day the subject of so much misguided criticism as the new buildings of Chicago, for in this day and generation wholesale condemnation sometimes passes for criticism. The popular mind is no more right in its estimation of Chicago architecture than it is in the hundred and one other cases in which prejudice asserts itself to the detriment of right and truth. In forming a correct estimate of Chicago architecture it is absolutely essential to judge it from the standard of Chicago—by Chicago conditions, not by Chicago taste, for the latter does not enter into the designing of Chicago structures. Chicago buildings, like all other modern buildings, are modified by the conditions calling them into being, and if it is necessary that Chicago have tall, large buildings, surpassing in magnitude similar structures in the East, it ill becomes an eastern critic to find fault with them simply because they are tremendous. He had best congratulate himself that the designs are so successful, that they so clearly express what they are intended to, and that they so admirably meet architectural, constructional and æsthetic conditions. For this is just what the new Chicago office buildings do, though their actual merits are far from being understood or appreciated in the East, where traditionary forms of building necessarily have a stronger hold than in the West. The call for severer treatment for which our contemporary asks is very clear evidence that it has never tried to view Chicago buildings from a Chicago standpoint, but being unable to comprehend their wide departure from ordinary methods, has supposed them to be something to be censured. Fortunately Chicago architecture can afford to ignore the assaults of such critics, but it nevertheless remains one of the most serious blots upon our architectural intelligence that such admirable and thoroughly modern structures as the Chicago architects are giving us, in their newest creations, should be both misrepresented and misunderstood by the people whose greatest pride should be in extolling some of the very few wholly excellent things America has produced in architecture.

NO ONE would venture to write on the comparative history of Sanscrit roots without first gaining some acquaintance with the general aspects of the subject. If we were to judge from much that is written on architecture, it might almost be supposed that no especial acquaintance with the art was essential in forming an opinion on it. This has been the real cause of the inappreciation of Chicago buildings; people have been unable to understand what they meant. Their high walls and wide façades seemed but so many plain brick walls with so many windows cut in them, a door below and perhaps a cornice above: all the rest plain and uninviting as a rock. Grant that such is the truth, what of it? Should one measure the architecture of a church by the requirements of a warehouse? Is the Greek to be judged by the Egyptian? Is the factory to serve as the criterion for the dwelling? The comparisons are preposterous, yet not more so than the insistence of the popular mind that Chicago buildings should be other than they are. They are high because the value of land is great, and the business of the city confined within a small area. They have the incomparable advantages of broad fronts, in which, as a rule, they are far superior to New York buildings, which are often painfully narrow. And then, above all, these things are expressed in the design, forming in fact, its basis. In a number of the newer office buildings of Chicago the traditions of the façade have been cast to one side; there is no grouping of parts or arrangements, scarcely any wall masses, nothing but plain walls with windows of identical design extending through perhaps sixteen stories, and affording no relief to a

somewhat monotonous surface. But it is not monotonous. No one condemns Niagara because it is high and broad. It is not the elements of Chicago buildings which make them unappreciated, but the hold that tradition has upon cultivated readers and students. A broken façade, in which the architect has made the most of his opportunities and been given considerable license, may, sometimes, be a thing of beauty. But when stretched out to sixteen or eighteen stories the most skilful arrangement becomes meaningless, the most refined poor, the most scholarly grotesque. The Chicago architects have been wise enough and brave enough to recognize this fact, and because they have done so their buildings rank among the most successful business structures in America, and as in this America leads the world it is no eagle's scream that says they are the finest structures of their class in the world. They are not palaces, nor historical studies, but modern office buildings, Chicago business buildings, which New York, with its towering claims to superiority, has been unable to equal, much less excel.

CHICAGO architecture is by no means an architecture of externals alone. The plan of a building is quite as important as an expressive and truthful façade. There is not, of course, the opportunity for individual designing in the planning of a series of office buildings as in a similar series of dwelling-houses, but the plans of Chicago buildings, as the Masonic Temple, the Unity, the Title and Trust, the Manhattan and a host of others—their number is legion—exhibit great economy of distribution and much ingenious adaptation of light space. More noteworthy are the decorative elements, because Chicago is so much talked of as a city of high buildings that it is almost necessary to go there to ascertain that this city of plain exteriors contains some of the finest decorative work. The interior of a building is as important to the architect as the exterior, and hence any description of Chicago buildings which ignores—as the series in *Harper's Magazine* a few months ago did—their interiors is very far short of presenting a true picture of their development. The Auditorium Building is a case in point, a structure whose immense granite and stone fronts are fairly familiar, and whose bulk, in some minds, makes it the most noteworthy edifice in America, as it certainly is one of the most impressive. Yet great as are the constructional merits of the Auditorium, its art qualities are not less important, though perhaps less well-known. The visitor who sees only its exterior sees only a part of it. Within, the theater, the public parts of the hotel and the banqueting-hall, are most splendid pieces of artistic decorative work—for all decoration is not artistic—well kept down within proper limits, and yet exhibiting an amazing fertility of artistic invention and design. And this splendid specimen of decorative architecture is a product of Chicago, that inland city we of the East have delighted to regard as the synonym of glaring taste and barbarous invention. The World's Columbian Exposition will not have been in vain if the true artistic and architectural status of Chicago be made known to the outer world.

IT is so seldom that two of New York's daily newspapers agree on any question that it becomes especially remarkable that two of them should be a unit on an architectural subject. Yet this is the very spectacle to which the good folk of New York are now being treated, and it deserves comment not only from its singularity but from the growing interest architectural matters must have among the people when two leading organs of opinion not only entertain similar views on such a subject, but devote a portion of their valuable space to their consideration. It is true, when it is remembered that the subject is a new City Hall for the metropolis, the strangeness of the discussion is not so singular as it appears at first sight, but even so unpromising a subject is welcome if thinking people can be induced to give architecture in any form serious thought. There is much truth in the statements of the city officials, albeit one would scarcely look for architectural enlightment in such quarters, that New York possesses no architectural building worthy of its position, wealth and

intelligence. It may be doubted if municipal architecture anywhere in America is a desirable commodity, but there is ample room for New York to improve in this respect. There is nothing more comical in the whole agitation than the tears the newspapers, whose buildings as a whole are notorious violations of architectural taste and sense, shed over the present City Hall of New York. A mild, unpretentious, unobtruding structure it certainly is, but why it should continue to encumber valuable land, or why the city should be forced to expend millions in obtaining a new site for no other reason than to preserve it, would be hard to find. The merit of this building is negative only, in not being what it might be. Architecturally it would be easy to be worse, but its usefulness, which is the real test of the merit of a structure of that kind, has long since passed away, and with it, all good reason for its preservation. The course of the *World* and the *Sun* in calling for its destruction, together with the other buildings in the park, and the erection of a single new structure in their place, is thoroughly in accord with the dictates of common sense.

THE most amusing thing in the City Hall controversy has been the statement cast far and wide that the irregular site of the *Staats-Zeitung* building would not admit of an architectural structure—that any building erected upon it would lack the dignity befitting the municipal buildings of the metropolis. Without expressing any opinion on the merits and demerits of this site, it may be permitted to remark that such an opinion is a most severe reflection upon the architectural knowledge of the community. It may, indeed, be granted that a regular building cannot be built upon an irregular site, but this proposition by no means implies the impossibility of preparing a plan which will fit the ground, and then a design which will fit the plan. The trouble arises not in an inherent difficulty of an irregular site, but in the supposition that a building to be "architecture" must be thoroughly and entirely regular. The question is one that depends on the style of the building, not on the form of the lot on which it is erected. If the proper style for a municipal building is Renaissance, then an irregular site carries with it certain difficulties which would not be apparent if another style, as the Romanesque or Gothic, were employed. After all, the true question is the proper adaptation of the building to the site, a due conception of the real problem at hand, and a genuine and earnest attempt to solve it. A thoughtful and suggestive paper in the *Architectural Record* for March on "Architecture as a Fine Art" by William Nelson Black touches on this point, and would form most instructive reading for those who labor under the impression that odd-shaped lots are drawbacks to architecture. As Mr. Black pertinently points out they are indeed so if they are not considered in the design of the building, and he cites several instances in New York where a total disregard of this very obvious proposition has led to most unpleasant results. His suggestion that such situations should be treated in a picturesque manner, or at least in a freer manner than is desirable in a regular location, is entirely right. It is scarcely too much to say that the violation of this rule has frequently led to most disastrous results in American architecture. It is simply the application of common sense to architecture and this, more than any one other thing, is what we need in current work. But it must not be supposed that because we have those among us who could, if need be, design suitable structures for irregular locations, that the *Staats-Zeitung* site is a good one for New York's new City Hall. The final location of this edifice probably will not rest upon architectural considerations and this question need not be considered in this place.

IN his book on "American Architecture," Mr. Montgomery Schuyler strangely enough reverses what should be its true title by adding the word "Studies" to his title page. Properly speaking, his book is not a book that treats of American architecture as a whole, as doubtless the author would be the first to admit, but it is a little unfortunate that he should have reversed

his title so as to make it seem to be what it is not. The essays gathered in this little volume have all appeared in the popular magazines, but it is not the less pleasant to have them in book form, and perhaps better so, because it enables the reader to gain a clearer idea of Mr. Schuyler's point of view as a critic than is possible in papers published at irregular intervals. An author has every right to limit the scope of his work in whatever way he sees fit, but it is a little startling to open a book purporting to be a series of serious studies in American architecture and find only one plan in it, and that of a building not even erected. In his introductory chapter the author deplores the estrangement between architecture and building which has become so marked a characteristic of modern work that if the fronts of most of our structures are scrapped off the architecture has been wholly removed. Yet the critic who is wise enough to make this comment on the works of others falls into the same error himself by totally neglecting interiors and plans, while such practical subjects as construction and building methods do not seem to concern him at all. All of this would be quite right in itself if the book had not been issued as a review of recent American architecture and given a title that does not express its scope. The subjects treated include, with the introductory chapter, essays "concerning Queen Anne," "The Vanderbilt House," "The Brooklyn Bridge as a Monument," "An American Cathedral," and two chapters on western architecture, Chicago and St. Paul and Minneapolis. The chapter on the "American Cathedral" is strangely enough concerned with the design prepared by Mr. Richardson and not carried out. The subject would seem, at this time, to be of sufficient interest to have warranted the author's taking the actual cathedral of Albany or the proposed cathedral of New York as a text. He is clearly in error when he suggests that the boarded ceilings of Peterborough and Ely cathedrals—in speaking of vaulted roofs—were "make-shifts," and he surely would not have spoken of metal rivalling stone in durability as a building material had he been aware of the fact that the Pennsylvania railroad is substituting stone bridges for iron ones on its system because the latter material has been found wanting in the quality he claims for it.

UNDER a new law passed at Albany the various building bureaus of New York City are to be united in a Building Department. The Mayor has given his support to the plan, and with the united action of architectural and building fraternities it is highly probable that this much-needed reform will become a fact. At present building operations in the city of New York suffer serious inconvenience through being under the control of three separate bodies, none of which are themselves independent, but portions of other departments. There is a bureau of buildings in connection with the Fire Department, and bureaus of plumbing and light and ventilation in the Health Department. The superintendence of buildings in a great city should be of sufficient importance to require a distinct organization of its own. The present arrangement entails very considerable extra expense through the duplication of plans and much loss of time and unnecessary journeys between different parts of the city. The item of cost of drawings is alone sufficient reason for establishing the new department, while much more thorough and satisfactory work must result from placing building operations under the control of an independent organization with its own employés and its own head directly responsible to the Mayor. Much of this responsibility is lost under the present system, in which closely connected parts are widely separated and one of the most important objects of municipal care treated as minor parts of other departments with which, properly speaking, they have no organic connection. It is sincerely to be hoped that "practical politics" will not prevent this very necessary reform from becoming really effective.

THE singular controversy that recently agitated Great Britain on the status of architecture, whether it be a profession or an art, which was thoroughly threshed out

in the London daily press a month or so ago, and which even penetrated the sacred precincts of professional literature, is touched upon by Mr. Morley Horder in the April number of the *Magazine of Art*. The English press seemed quite unable to answer the question satisfactorily, perhaps, as Mr. Horder suggests, because none of the parties concerned wished it answered. At the most it is not a subject of the first importance. We have with us, and doubtless always will have, men who look upon architecture as a trade, and others who view it as an art. The former may be in the majority since the tendency of the time, in this country especially, is towards the utilitarian, and the man who erects a great building economically is likely to be looked upon as a greater architect than he who might produce the most wondrous product of the fancy. Much of the trouble people experience in forming an opinion on such a question arises from confusing modern conditions with ancient or mediæval. Architecture does not in any sense fill the same place in our civilization as it did in the middle ages, for example, notwithstanding the enormous number of buildings we are yearly erecting, and the really great progress we are making in construction. It is equally an error to divorce architecture from building and make two arts that are really one separate entities. To properly estimate the position of the modern architect we must take into consideration all the conditions under which he works, and unless this is done, and he is judged by these modern standards it is useless to speculate as to whether he is an artist, or simply an ordinary member of an ordinary profession. The architect who looks only at the art side of his work, as distinguished from the practical and constructional side is apt to miss the opportunities of life. Our age, most unfortunately, is not one that encourages pure art in architecture, however much it may do for painting and sculpture.

THE mortality of architectural writers has been somewhat unusual this month. Foremost in the list stands Edward A. Freeman, LL. D., D. C. L., who, although better known as an historian than an architectural writer, was a master of the latter art and made many remarkable contributions to its history. This, indeed, was the topic that first occupied his mind, his earlier publications being in this field of work. These included a "History of Architecture," "Church Restoration," "Essay on Window-Tracery," "Architectural Antiquities of Gower," "The Architecture of Llandaff Cathedral," "The Antiquities of St. David's," "History of the Cathedral Church of Wells," and "Historical and Architectural Sketches." His historical works were much more important than these, his fame being ensured by his great "Noman Conquest." At the time of his death, which was quite unexpected, he was engaged in a monumental "History of Sicily from the Earliest Times," of which two volumes appeared last year. Mr. Freeman was one of the very few writers who thoroughly appreciated the value of architectural study conducted in the right spirit, and he was constantly urging its importance as not second to the study of politics, philology and kindred sciences of which general history is chiefly composed. Though he never lost an opportunity of stating this point of view, it cannot but be regretted that so accomplished a scholar and one so admirably suited for the work should not have made a more extended effort for bringing about this result than his multifarious studies permitted him to do.

Mr. Arthur Lyman Tuckerman, whose death shortly preceded that of Mr. Freeman will perhaps be better known as the architect of the Metropolitan Museum building in Central Park than from his writings, though these included several works. He was the head of the Museum art schools.

CIVIL ENGINEERING.

Conducted by T. Graham Gribble.

THE valuable experiments of the British Association committee in Section C upon Tidal Action in Estuaries has been completed and the report just published brings to a close the record of continuous experiments carried on night and day upon two tanks from June 22, 1889, to August, 1891, which have each accomplished upwards of 1,200,000 tides, answering to the experience of 2000 years. The committed was composed of the following gentlemen: Sir J. N. Douglass, Prof. Osborne Reynolds, Prof. W. Cawthorne Unwin, Messrs. W. Topley, E. Leader Williams, W. Shelford, G. F. Deacon, A. R. Hunt, W. H. Wheeler, W. Anderson and H. Bamford. The operations were carried on at the Whitworth Engineering Laboratory in Owen's College, Manchester, under the supervision of Mr. Greenshields. The tanks are models of V-shaped estuaries forming the mouth of a river fifty miles long and having sandy beds. The committee consider that the results have fully established the laws governing the action of tidal streams, the accuracy of their formulæ for the conditions of equilibrium and consequent open waterway, and finally for the application of the method to any special case in order to arrive with certainty at the prospective results upon an estuary from works of improvement at its mouth or along the tidal river which flows into it. The investigations were carried on with a view—

1. To obtain further information as to the final condition of equilibrium with long tidal rivers entering the head of a V-shaped estuary.

2. To obtain a more complete verification of the value of the criterion of similarity.

3. To investigate the effect of tides in the generator diverging from simple harmonic tides.

4. To determine the comparative effect of tides varying from spring to neap.

5. To investigate the effect of prolonging the walls of the river into the estuary, through the bar which was below low water, with prolongations reaching up to low water, and others reaching up to half tide, this being done in both models, so that the similarity of the effects might be seen.

6. To investigate the effect of rendering the estuaries unsymmetrical by means of large groins, and so to test the laws of similarity obtained in the symmetrical estuaries as applied to unsymmetrical estuaries.

The general results and conclusions are as follows:

1. *Conditions of equilibrium with a long tidal river entering at the top of a V-shaped estuary.* From this year's experiments it appears that if the length of the tidal river, reduced to a 30-foot tide, is fifty miles; or taking R for the length of the tidal river in miles and h for the rise of tide at the mouth of the estuary in feet, if

$$R = 8.5 \sqrt{h}$$

the river will keep open so that the tide will rise to the top, the sand falling gradually from the top of the river to the level of about mean tide at the mouth.

That the depth of water in the river at the top of the estuary increases rapidly with the length of the river, and when

$$R = 12 \sqrt{h}$$

the level of the sand at the mouth of the river will be more than h feet below the level of low water and the bottom will be below low water level for more than half the length of the river above its mouth.

2. *Criterion of similarity.* One tank was made larger than the other. The criterion of similarity $h^3 e$ where h = rise of tide and e = the vertical exaggeration as referred to a 30-foot tide. In the smaller tank

this criterion could not be raised above 0.09 but on diminishing the range of tide in the larger tank until the criterion had the above value, the results were still similar. Two possible conditions of equilibrium were deduced from these investigations, the one as exhibited in the larger tank in which the tide, rising up to the top of the river kept the sand low in the estuary, the other as in the smaller tank in which the sand at the top of the estuary rose to high water level, as it would do if there were no river, choking the mouth of the river except so far as necessary to allow the land water to pass, and so preventing any tidal action from the river.

3. *Action of tides varying from spring to neap.* Following deductions were reached:

(*a*) That the conditions of final equilibrium in all cases with spring and neap tides was the same as that with uniform tides having the same rise as springs, and much greater, essentially different from that with a uniform tide having a rise equal to the mean rise of spring and neap tides.

(*b*) That the rate of action, with the varying tide is much smaller than that of a uniform tide having the rise of the spring tide. The ratios being definite, about 2.5 to 1.

(*c*) That the limits of similarity obtained for all spring tides hold approximately for tides varying from spring to neap.

4. *Effects of prolonging the rivers into the estuaries by walls below high water.* Similarity of result in both tanks supports the conclusion that: vertical walls having the horizontal direction of the current in a straight tideway and terminating well below high water, produce but little effect on the distribution of the sand between them, so long as the passage is freely open at both ends, but that if the passage be blocked at one end, they form a bay in which the sand rises at the head.

5. *Effects of the tide in estuaries not symmetrical.* The result of the experiments show conclusively—

(*a*) That the laws of similiarity found for symmetrical channels with uniform tides hold with sinuous channels for uniform or varying tides.

(*b*) That the greater uniformity of the depth of sand on cross sections of models with symmetrical boundaries than with actual estuaries, does not exist when the banks are equally irregular.

(*c*) That the circulation caused by the unequal flow of the tide in model estuaries tends greatly to take the sand out, and that the natural tendency in an estuary to scarp the boundaries so as to increase its sinuosities tends greatly to the deepening of the channels.

(*d*) That in the models with boldly irregular boundaries, the tidal ripples are much less frequent than in the symmetrical models, being confined to places where there are no cross currents, as in actual estuaries.

The report is accompanied by fourteen inset plates of diagrams giving contoured maps of soundings and profiles along the center line. The apparatus for generating the tides is also illustrated.

MR. LINDENTHAL'S 3100-feet span over the Hudson will touch the top notch in bridge building.

It is an interesting development of the suspension system and one which will doubtless contribute largely to experience in that principle of construction. The most attractive feature about the bridge from an engineering point of view is the fine clear sweep of the roadway, giving uniform height to the shipping. This feature no doubt "fetched" the board of army engineers more than anything else. It would be presumptuous to attempt a critique of the efficiency of this great structure as compared with the cantilever, without getting to the bottom of the engineer's calculations. Mr. Lindenthal has been both inventor and constructor of suspension bridges for years back and is well fitted to undertake such an enterprise. The army engineers who have given their approval to the design have also doubtless satisfied themselves as to its strength and stiffness, and whatever Mr. Wisner may think of army engineers' own works, he will probably admit their critical powers when dealing with the projects of civil engineers.

In these chit-chat editorials one may

however, suggest without impertinence cursory questionings which suggest themselves to engineers who have only seen the perspective view of the bridge. The first impression which occurs is that in so immense a structure there must be something more or less indeterminate about the calculations. There never has been a composite suspension bridge yet built in which the stresses were wholly determinate. Prof. DuBois has suggested a sliding girder for producing determinate stresses, but it has not materialized yet. The initial undertaking of erection bears strongly upon the determination of the stresses, the cables with their connecting members would form during erection a catenary curve, but when loaded with the roadway would be transformed into a parabola. The resultant strains on the bracing would entail some curious equations.

As regards load strains, the dead weight being three and a-half times as much as the maximum live load, the bridge will not require the same relative stiffness as a shorter span, but the effect upon the cables of unequal load will nevertheless have to be determined and combined with the effect upon the roadway girders. The analysis in standard text-books of the suspension bridge with stiffening girder exhibit at a glance the elaborate nature of the formulæ even when the cable is a simple funicular polygon, not a ribbed inverted arch, as in the Lindenthal bridge.

Load troubles all bridges and more especially suspension bridges in three ways, by deflection, deformation and vibration. The first is easily determined, the second not so readily, the third, subtle and dangerous, defies the mathematician and yields but partially to the practical mechanic. The writer saw the other day some three-inch pins taken out of a fifty-foot span truss in which the eyes had worn a sixteenth of an inch into the pin. The makers were an Eastern firm of considerable repute. The truss had been erected only twelve years and there was no sign of corrosion.

The suspension bridge possesses essential economic features, but its lightness renders it more liable to deformation. The Lindenthal bridge is something like Eads' great arches at Saint Louis only inverted and (one would say) with comparatively much lighter ribs. The bending moment produced by an unequal load is precisely analogous to that in the Saint Louis bridge and the ribbed connections between the cables would have to withstand this bending moment by their own moment of resistance as contrasted with the case of a framed suspension bridge or a cantilever which possesses a leverage of the total depth. If the mathematician has been able to work out to what extent deformation and vibration will be produced in these ribbed members, he must be "a terror" on figures.

In further comparison with the cantilever, the suspension bridge having its roadway hanging free, derives no support laterally against wind pressure from the main members. The roadway requires to be constructed as a horizontal girder, and therefore the wider the better. In the Forth Bridge, for instance, one is struck by the narrowness of the roadway as compared with the length of span and is prompted to enquire whether economy could not be obtained by greater width instead of by such a huge mass of iron rigidly connected with the towers. Especially in bridges connecting two great centers of population the traffic upon which is bound to increase, it might be good policy to build the bridge of much greater width than would be necessary for present requirements and thereby obtain at the same time resistance to wind pressure varying as the square of the width.

Since writing the above we concluded to submit the MS. to Mr. Lindenthal, and have been favored with a reply from him at some length. We hope to say something more upon the subject next month, but a few words of explanation from Mr. Lindenthal's letter as far as space will permit will be of interest as a rider to our remarks. With regard to the army engineers, these gentlemen restricted themselves to the consideration of the headway.

As to stresses in the bracing produced during transformation from the catenary to the parabola, Mr. Lindenthal says: "The

bracing between the cables which appears in all lithographs as of the double triangular intersection, has been changed, and will consist of vertical web members with adjustable diagonals attached to pins, imbedded in the wire cables. The diagonals to be adjusted after the whole bridge is erected." Counters of trusses are generally adjusted in this manner, but not members under heavy strain. It is not an expedient which one would choose if there were any other way out of the difficulty.

The arches themselves are hinged, rendering the stresses more easily determinable than in arches with fixed ends. Mr. Lindenthal considers the problem as simple as that of the Washington arch bridge over the Harlem river. We must reserve any expression on that point until particulars are available as to the method of erection, which no doubt will be made public in due course. The erection is obviously the crux of the matter.

Mr. Lindenthal states that the calculations will be verified by independent mathematicians working separately, and no doubt all possible means will be taken up to the limit of present knowledge and experience to obtain certainty before commencing so vast a work.

But the mathematicians will not have to determine merely whether when the bridge is completed, every member will be adequate in its place to do its duty, they must also determine the initial static condition produced during erection. Supposing, for the sake of argument, that the cables are swung freely into approximately parallel catenaries, the vertical web members introduced, and the adjustable diagonals. The bracing will then be under no stress whatever. Supposing further that the roadway is then suspended so as to bear equally upon the two cables, deflecting them into approximately parallel parabolas. By comparing the equations to the two curves, it would be determinable by what amounts the several braces had tended to alter their length during the process, but inasmuch as the vertical web members are not adjustable and the diagonals themselves are not self-adjustable, it would remain to be determined, if possible, on the one hand what alterations of length had taken place arising from the elasticity of the material, and on the other hand what stresses had been produced thereby. The only practical thing to do would be to tighten up every diagonal that was slack. This operation would secure the action of every member, but it would not prove that the tight members had not been subjected to severe strain.

An alternative method of erection would be to load both cables equally with the suspended roadway before introducing the bracing so that the initial stresses of the bracing would be nil. There would then be no necessity for adjustable members. With regard to vibration in addition to what we have said previously the subject may be put in a sentence thus: The suspension bridge is the mechanical reverse of the arch. The arch having rigid ribs is adapted to rigid bracing, but the suspension bridge having flexible ribs is not well adapted to rigid bracing. In the North river bridge, the pins for the adjustable bracing are imbedded in the wire cables. If there be any sensible vibration upon those pins, they must sooner or later require renewal. When further details are published, both as to construction and erection, we shall probably know how the engineer gets rid of the vibration or else provides for the renewal of the pins.

WHAT is the matter with New York Rapid Transit? During the excitement of the public sessions of the commission last year, Mr. Jay Gould enquired one day at some railway meeting in Wall Street whether there was yet any stock to be sold and on being replied to in the affirmative he explained that he only asked from motives of curiosity, because it was rumored that all of it had been taken up by the newspapers. If so what is the matter with the newspapers that they do not bull their stock? The *Popular Science Monthly* has a fresh contribution to the subject in the shape of a report by United States Commissioner of Labor Carroll D. Wright. He treats the subject as more than a question of economics or of business convenience and claims for it a pos i

tion of social and ethical importance of the first rank. This is surely right but ethics fail to elicit as much capital as convenience. The maximum range of population in New York is 474 per acre in Ward 10. In Chicago it is 116 in Ward 16. The people may be bottled in Manhattan Island for some time to come before ethics will help them and the citizens themselves are a long suffering people. After all, it is not as bad as in many a city in China, and though American cities are rapidly imitating the Chinese rabbit-warrens in their mode of living, there is still a margin of superiority for Western civilization. The difficulty is not one of transit, but of traction, *i. e.*, who is to get the "pull" amongst the diverse pullers and the multifarious strings? The people who should find the money are all right; they naturally prefer to suffer than to pad somebody else's pockets or to spend more money upon a scientific diagnosis of their sufferings without corresponding relief. Monarchism and bumbledom and King Log still survive in the Old World but boss rule and boodle and King Stork are supreme in the New. Some think the rule is getting stronger and that it has come to stay, but they reckon without due consideration for the American back-bone. The people must get what they need and the press will have to help them to get it. They pay 71 cents per head per annum for street cleaning in New York as compared with 8 cents per head per annum in Chicago, but New York streets are scarcely 900 per cent. cleaner than those of Chicago. Would not the 8 cents clean New York streets if the pavement were in proper condition, and would not the balance provide for Rapid Transit? Buffalo with its 100 miles of asphalt pavement only costs 5 cents per head per annum to keep clean. [See Census Bulletin.] Pending any definite action towards real Rapid transit, the efforts to get cable-roads have been like pouring money into a bag with holes and they are only a make-shift at their best. People have got to be moved at twenty or thirty miles an hour right through the big cities or else the cities themselves will die from a kind of congestion of the lungs.

PRESIDENT HARRISON has made his third appeal to Congress for legislation in the matter of automatic car-couplers. In the year ending June 30, 1890, 369 brakemen were killed and 7841 maimed. He points out that while Government spends one million dollars annually to save the lives of shipwrecked seamen, it does nothing for the poor brakemen. A bill has been introduced by Senator Cullom of Illinois with the view of carrying out the presidential suggestions, neglect to furnish these safeguards on the part of the company to be a misdemeanor and punishable by a heavy fine.

By all means make the railway companies look after their servants but let that stand instead of cinching them. By all means make them provide for the comfort and security of their passengers but let that stand instead of robbing them.

The railroad cinching policy of Texas is being tested by the farmers themselves in whose interest it has been done. They have nearly killed the goose that laid the golden eggs, and are startled to find that the half million to a million dollars which their present friends have "saved" on rates has recoiled upon them by a fall in the price of cotton. The producers have in fact been generous to outside middlemen at the expense of the domestic enterprises which have given them the prosperity they enjoy, and have themselves reaped nothing from it. According to the *Railway Age*, out of the 9000 miles of railroad in Texas, not more than a few hundred miles of one single company have ever paid dividends on stock, and only two of the companies pay the interest on the bonds. Foreign capital is choked off and the State will presently realize that it is easier to quench the courage of investing capital by robbing it of its legitimate incentive than to revive it when it has died down. If there were more railroad men in Western Legislatures and fewer lawyers, it would be none the worse for the farmers and much better for the country.

A SPICY little struggle has been going on at Chicago between the Baltimore and Ohio and Illinois Central railroads with

regard to access to the World's Fair. The latter company has at present the only means of communication. Efforts have been made to bring down the traffic from other roads by cross lines, either elevated or on the surface, but hitherto what with weakness of capital and tardiness of city legislation, nothing has come to a head, and a traffic which is estimated to reach a maximum of 125,000 people per hour is unprovided for. The two problems of how to get there and how to get about when you are there are still unsolved, and as the time is running so close, the gravity of the question is increasing. The Illinois Central began to build a road to block the B. and O., and the B. and O. laid tracks to block the I. C. The B. and O. obtained an order from the city to tear up the I. C. tracks, and the I. C. obtained an order from the court to enjoin them from so doing. Special engines and wagons of both companies hurried down to the field of battle. The B. and O. with the city authorities got in ahead and tore up the I. C. tracks so that on the arrival of the injunction there were none to save. Meanwhile the expectant world waits patiently to know how it is going to get to the Fair. There is likely to be a good opening for aquatics.

THE new railway tunnel for Chicago urban transit, Mr. S. G. Artingstall, engineer, is approaching completion and will afford considerable relief to the present overburdened means of surface locomotion. It passes under the Chicago river and will be exclusively used by the West Chicago Street-Railroad, operated by cable. This restriction is a most necessary one. The La Salle Street Tunnel has been the scene of horrible accidents mostly from casualties on the cars themselves but also from pedestrians and buggy riders taking their chance of getting through without being "sandwiched." The new tunnel is a three-centered brick arch seven rings thick except where it passes under the tracks of the Chicago, Burlington and Quincy Railroad and three other railroads where the thickness is increased to ten rings. The river is nearly 200 feet wide between quay walls and the total length of tunnel over approaches is 1513 feet. The excavations are in heavy semi-fluid clay, very much of the same nature as that of Michigan through which the Port Huron and Sarnia Tunnel, commonly called the St. Clair Tunnel, was built. It swells like the blue clay of the London basin, but is not so dark, compact or heavy. The superincumbent weight of clay is not great, never exceeding a depth of 24 feet over the extrados, but the chief difficulty has been in the surcharge of the adjacent buildings one of which is a brick structure seven stories high. Mr. Artingstall has adhered to old established methods of core construction by timbering and underpinning although considerable work was entailed in maintaining the tracks of the four railways. These were supported on pile bridges before the work was commenced. The river section is being built in coffer-dam, one-half at a time.

THE City Corporation of Birmingham, England, has lately made some lengthy investigations of the various methods of sewer ventilation and the report of the committee is well worthy of attention. It reveals the paucity of inventive genius as applied to that most important department of engineering. The open ventilator at the crown of the street, allowing the gas to escape freely into the air appears to be the "pis aller" of sanitarians. Even upcast shafts with cowls, although to be increased in number by the Birmingham Corporation, are only recommended by the City Engineer as supplemental to rather than in substitution of the open grating at the road surfaces. The open grating is odoriferous, but its exhalations being diluted are as innocuous as it is possible for sewer-gas to be. In a beautiful country town of England where there are numerous grade-crossings of railways and also the open grating system, the grade-crossings are indicated by the warning, "Beware of the trains." A wag, turning the "t" into a "d" has expressed the needed caution to pedestrians. Keeping to the sidewalk they are safe, but woe betide them when they cross the street over a ventilator.

MINING AND METALLURGY.

Conducted by Albert Williams, Jr.

EXPERT Testimony in Mining Title Suits, under existing practice, stands on the same level as the *ex parte* evidence of doctors and professional toxicologists in poisoning trials. The expert witnesses, whether the issue be one of geology and mining law or of medical jurisprudence and chemical analysis, are employed for the prosecution or defense, and like the hired attorneys on either side feel that they ought to earn their high fees by presenting the best aspect of their employer's case. They may not go so far as to suffer the imputation of perjury, but they allow their opinions to be colored in accordance with the elasticity of their consciences and their conception of the obligations of professional ethics, and at least go so far as to gloze over a *suppressio veri* with comparative equanimity. The fact that most of the experts stand ready to testify on either side of a case that is at all debatable throws discredit on their evidence in the minds of judges, juries and the public. Regarding a recent mining suit, the *Mining Industry* is decidedly caustic in summing up the situation:

"There are ten expert witnesses on each side, with the usual amount of swearing and 'cussing.' If Gov. Routt had not vetoed the expert witness bill, the court would have appointed experts who would have been unprejudiced, and there would have been some profit in reporting their evidence. As it is now the experts are hired advocates of the side employing them. No one can expect to get the whole truth out of them, if that whole truth would be an injury to their side. The whole thing is a farce and satire on justice."

But the proposed plan of making the expert witness in cases involving technical points *amicus curiæ*, as is done in some foreign courts, seems to make no more progress toward realization in mining than in medical jurisprudence in this country.

The Ratio of Dividends to Average Market Values of Mining-Shares forms the subject of an interesting study in the *Engineering and Mining Journal*, which, in summarizing the results for 1891, remarks that "it would appear that the investor in Lake Superior copper mines is satisfied with a return of from 8 to 8½ per cent. on his money. These mines have long records as steady dividend-payers: they are located in wonderfully strong and uniform lodes; and they are opened a long way ahead; so that the prime point of consideration with respect to their immediate value is the price of the copper." Turning to the silver mines, the *Journal* classes the Ontario, Daly, Granite Mountain and Bimetallic in a group by themselves, because of their similar character in regard to regularity of veins, development in advance of stoping and because of their shares being held almost entirely as investments. Their dividends have agreed very closely, ranging between 13 and 16 per cent., which our contemporary thinks may be taken as the return expected from investments in these and stocks of similar character. But it is hard to deduce any fixed rule. It used to be said of Nevada dividend-paying shares that they ought to pay about 2 per cent. per month on their quotations; that is, that the investor should get the whole of his money back in two years—the assumption being that the average bonanza would not last longer. Of course a mine is always worth something beyond the profits in actual sight, on the chance of further discoveries. Under the more prudent management which finds favor at present the future of a mine having reasonable regularity ought to be assured for some time ahead, when it becomes possible to figure out what a fair dividend rate would be. As a matter of fact, the dividends on gold and

silver mining-stocks in 1891 ranged all the way from 1 to 40 per cent. on their average valuation, and this wide variation indicates how differently investors and speculators look at the matter. Now that there are relatively more of the former and fewer of the latter interested in mines, attention is being directed to this question of the just relation between the price of mining stocks, current dividend rate, amount of ore reserves and the time element.

Lignite Briquettes are proposed to be made in Texas. As is well known, the lignites of the West are an easily-mined, abundant and cheap fuel, burning freely but carrying high percentages of ash and moisture. They serve a useful purpose for making steam and for domestic use; but rapidly deteriorate when exposed to the weather, the poorer kinds slaking to a fine dust. There are considerable differences in their quality, but none of them are strong enough to stand the burden of the blast furnace, nor do they coke. Hence any method of rendering them available for use in place of coke, anthracite or even a strong bituminous coal, or that would make them stand transportation and exposure better, would be of great benefit. But when the proposition takes the latest form of manufacturing briquettes in which finely-pulverized "chemicals" (character not stated) are to be intimately incorporated, and the whole compressed by powerful machinery into blocks 8" square or oblong, and the selling price to be put at $1 per ton after allowing for cost of mining, "chemicals," manufacture and handling—the scheme does not appear very promising. In view of the poor success reached in making briquettes of anthracite culm, which can be had without cost on some places or even with a bonus for removing it out of the way, it would not seem that lignite, a less favorable material, holds forth much encouragement for briquette making by any process yet tried or suggested. Doubtless a satisfactory technical result is attainable; but would it pay? However, Mr. J. C. Newbury states (in the report of the Department of Mines, Victoria, Australia, for 1890) that according to his investigations brown lignites cannot be made into briquettes by pressure and tar, as they are too friable to handle after sustaining a pressure of 10.75 pounds per square inch. He has seen a good briquette, not easily broken, said to have been made by heating the lignite to the temperature at which the tarry matters are formed, and passing it immediately to the molds before they are given off.

A State Bounty for the Discovery of Gold Mines is urged by a Colorado journal on the ground that the yellow metal has been too much disregarded by prospectors of late in the search for silver lodes. The assertion is advanced that "the offer, if made, could be protected against abuse by proper safeguards"—which is extremely doubtful, to put it mildly. Also that "a reasonable reward for the discovery of new placers or [gold-bearing] lodes would impart a lively stimulus to the search for them * * * The State [of Colorado] can well afford to devote $100,000 a year to such enterprises; and, our word for it the production of gold would be increased tenfold in due time by this simple measure of encouragement." One would suppose that the natural reward always in view when seeking profitable gold deposits would be a sufficiently "lively stimulus" in itself. A good gold mine, if it cannot be worked by the locator, generally brings what it is worth in ready cash—often more. Even conceding that it is the business of the State at all, surely a find which is not remunerative is hardly a fit subject for a bounty. That is the kind of discovery for which it would be most frequently claimed. The other sort wouldn't need one.

Hydrogen in Metallurgy may possibly become a more important factor in the future than it is now, if a new method for producing it on the large scale proves to be as economical as is claimed. At present its use as a strong reducing agent is confined to laboratory work and the reduction of some of the rarer metals. The new process is based on the well-known reaction when a current of steam is passed through molten iron, the former being decomposed and sesquioxide of iron formed at the expense of the oxygen of the steam,

while the hydrogen is set free, to be collected or at once used. The iron oxide left, while still hot, is subjected to a current of hydrocarbon vapor from crude petroleum, and is reconverted into the metallic state. It is reported that the price can be reduced to 12 cents per 1000 feet, or 3 cents a pound, which is much cheaper than the common method of decomposing weak sulphuric acid by zinc or iron. At this comparatively low price hydrogen might become a practical agent in the reduction of metallic oxides which resist conversion by carbon heat, as aluminum, calcium, magnesium, etc., and silicon, boron and other substances valuable in the arts, but which require the intervention of the expensive elements potassium, sodium, fluorine and chlorine.

Electricity in Relation to Mining is the subject of a communication from Mr. Ernest Scott in the London *Electrical Review*, in which the author strongly urges the advantages of electricity for underground work over steam, hydraulic and compressed-air power—the latter being rated as almost its only rival. Summarized, the claims are:

1. Greater efficiency and therefore reduced first cost and expense in working than other mediums of power transmission over considerable distances—say over half a mile.

2. The greater ease with which the comparatively small copper conductors can be manipulated and kept in order, as compared with piping, especially where there are falling roofs or shifting floors. [Here Mr. Scott refers particularly to coal-mining. He does not, however, seem to give due weight to the difficulty of insulation in wet ground.]

3. The facility with which machines which require to be moved occasionally—for example, coal-cutters, pumps, drills, etc.—can be advanced along the roadways as the work proceeds, or taken about from one part of the workings to another.

Patents for Metallurgical Apparatus and Processes continue to be recorded in large numbers in the weekly lists of the Patent-Office. The titles run about thus: Mill for crushing ores, apparatus for treating ores, chloridizing ores of precious metals, treating powdery iron ores, ore concentrator, separating aluminum, amalgamating silver ores, separator, conveyor, manufacturing oxides of metals, machine for washing and grinding gravel, method of casting iron pigs, and so on, taken just as they come. In gold and silver metallurgy concentrators, amalgamators, pulverizers and leaching processes seem to be the favorite subjects at present with inventors, and almost rank with car-couplings. In 1884 some one took the trouble to search the Patent-Office records and found that in the eleven years previous 200 patents had been issued for concentrating machines, 168 for amalgamating machinery, 63 for furnaces of different kinds, 49 for ore crushers and pulverizers and 30 for miscellaneous "improvements" in working gold and silver ores. Since then the number has been vastly increased; but of the hundreds or thousands of patented metallurgical inventions few practical vestiges remain. The proportion of these metallurgical devices and methods which even get so far along as to receive trial on the working scale is small indeed, and the number of those which stand the ordeal of practice is of course still smaller. The trouble seems to be that most inventors are not familiar with the history and present state of the art, and do not take the trouble to find out what others have done or are doing, but rush wildly for a patent the moment the inspiration seizes them. As has been pointed out in recent contributions to this magazine, in many lines the margin for improvement has been cut down nearly to the vanishing point, which leaves little room for the inventor. Speaking generally, there is a more promising field for the introduction of labor-saving devices and small savings by automatic handling, utilization of by-products, etc., than in more ambitious or revolutionary schemes, and the mechanic is more in demand than the chemist. Certainly the openings for improvement are by no means closed yet. They never will be. Would-be inventors need not be discouraged from their efforts; but they ought to understand that they will advance faster

by closely studying the hints, failures and warnings of the past and familiarizing themselves with present standard practice.

"Specimen Ore" is not in great favor with most old miners, for the reason that it so seldom occurs in quantity. They do not of course object to excessively high-grade ore *per se*, and fully appreciate the advantage of having a given value contained in the least tonnage because of the increased economy in mining, handling and extracting it. But there is a prevalent idea that extraordinarily rich ore is usually a sign of small total production, and the prejudice has this much of foundation, that most of the great gold and silver mines have been in deposits of medium and low-grade ore, with a few notable exceptions like the Silver King, of Arizona, some of the Austin, Tuscarora and White Pine mines (Nevada), the Owyhee district (Idaho), Batopilas (Mexico), etc., and they do not forget the record of the Robert E. Lee (Leadville, Colorado), which turned out $118,000 in sixteen hours about a dozen years ago. But latterly this notion has received a rude shock by many remarkable strikes of high-grade ore. Among Colorado mines the Lamartine, with its rich stephanite; the telluride mines of Boulder county, the Breckenridge gold mines, some of the San Juan silver mines and the Aspen district, have furnished very rich ore in quantities far from small. In the last-named district the Mollie Gibson in a five months' run last year yielded $1,645,000. Among its shipments have been one carload of 24,360 pounds which sold for $19,000; one lot of 23½ tons which brought $76,600; another lot of 28 tons selling for $64,000; two carloads containing 135,000 ounces, and so on, while all sorts of wild rumors have from time to time been current as to strikes of "2-foot veins of nearly solid silver," (26,000 ounces) a "7-foot body of 9000-ounce ore," etc., in the mine. When the present owners have done with it they will have a great record to sell the property on. The Golden Fleece and the Ground Hog mines have turned out specimens half gold, and one lot of 1200 pounds from the latter mine was rated at $10,000. At Ward district, Boulder county, some gold ore worth $10 to $50 a pound was struck in February. From the new and booming districts big stories are of course to be expected; some Amethyst ore (Creede district) has gone as high as 7000 ounces per ton and Cripple Creek has furnished some wonderful specimens of free gold quartz. A magnificent collection of Colorado nuggets was exhibited during the session of the Western Congress at Denver last year, but this does not bear on the present question, as they represented many finds at different periods. Only a few weeks ago, however, as if to show that all the nuggets have not yet been found, three men at Riverside, California, washed out $750 worth of them and coarse gold in six days with the ordinary miners' pan. As to the older finds, tradition generally comes down to us in forms exaggerated in proportion to the lapse of time, but there are plenty of authentic records also. Yet there are San Francisco mining men who will not touch a property of the "specimen" class, and when a lot of nuggets worth about $3000 from a gravel mine were exhibited in New York two or three years ago, the show was thought to interfere with the sale of stock. A great deal can be said for and against "specimen" mines; but the fact is, there is no rule whatever.

King Solomon's Mines have again been relocated—In an entirely unexpected region, of course. This time they are in the Malay peninsula, where an English syndicate is at work developing them. Its capital is £1,000,000, but the account does not state what proportion has been paid in. As the reduction plant is a modest 10-stamp mill, it looks as though the company cannot be very flush. Mount Ophir, of scriptural renown, is near by—also of course. The report says that "the old rocks which were of too low grade for King Solomon's reduction processes, are being ground, and they average half an ounce [gold] to the ton"; but in another statement the average tenor of the ore is given at two ounces per ton. The "reef" is said to vary from two to nine feet in width, which does not seem any too large for a low-grade proposition. Very recently, however, comes information from still

another quarter which seems to support that eminent mining authority, Mr. H. Rider Haggard. An English traveller, describing ruins and objects of art found on the Zimbabwe river, in the interior of Africa, says that these are in no way connected with any existing race, but were left by the ancient Arabs. "It is obvious," he concludes, "that the ruins formed a garrison for the protection of a gold-producing race in remote antiquity. All ancient writers speak of Arabian gold in terms of extravagant praise. Little, if any, gold came from Arabia itself; and here in Africa gold was produced in large quantities, both alluvial and from quartz [?] from the remotest ages."

To what Extent the Energy of Dynamite may be directed by different placings of the cap is a question which is being discussed among engineers and in the technical press. Common black blasting-powder takes the line of least resistance—that is, it will blow out when given the opportunity, and do the least effective work the conditions permit. When nitro-glycerine and dynamite were novelties the action was so noticeably different that some persons claimed that the explosive actually sought the greatest obstacle for attack, an idea which the effect of a mere water tamping or the air resistance when dynamite is fired in the open, seemed to countenance, but which is supplanted by the explanation that the shock is so sudden that a weak or elastic tamping has not time to give way. The curious effects seen when dynamite in large quantities is accidentally exploded require further elucidation. Gen. Newton's well known experiments with crushing-pressure gages, arranged in ring form, do not point to any eccentricity of behavior. The only way to determine such questions is by systematic experiment and observation. Argument without tests is of little avail.

The Mineral Statistics of the United States for 1890, as compiled by the Division of Mining Statistics of the United States Geological Survey, are given in the accompanying table. Long tons are 2240 pounds; short tons, 2000 pounds. Values of the metals are as quoted at the commercial centers; of non-metallic products, at the points where produced:

METALLIC PRODUCTS.	QUANTITY.	VALUE.
Pig iron, long tons	9,202,703	$151,200,410
Silver, troy ounces	54,500,000	70,464,645
Gold, troy ounces	1,588,880	32,845,000
Copper, pounds	265,115,133	30,848,797
Lead, short tons	161,754	14,266,703
Zinc, short tons	63,683	6,266,407
Quicksilver, flasks	22,926	1,203,615
Nickel, pounds	223,488	134,093
Aluminum, and aluminum in alloys, pounds	61,281	61,281
Antimony, short tons	129	40,756
Platinum, troy ounces	600	2,500
Total		$397,334,207

NON-METALLIC PRODUCTS.	QUANTITY.	VALUE.
Bituminous coal, long tons	99,392,871	$110,420,801
Pennsylvania anthracite, long tons	41,489,858	61,445,683
Building stone		47,000,000
Petroleum, barrels	45,000,000	35,000,000
Lime, barrels	60,000,000	35,000,000
Natural gas		20,000,000
Cement, barrels	8,000,000	6,000,000
Salt, barrels	8,776,991	4,752,286
Phosphate rock, long tons	510,499	3,213,795
Limestone for iron flux, long tons	5,521,622	2,760,811
Mineral waters, gallons	12,910,708	2,031,189
Zinc-white		1,600,000
Potters' clay, long tons	350,000	756,000
Mineral paints, long tons	45,732	661,932
Borax, pounds	9,500,000	617,500
Gypsum, short tons	182,995	574,523
Grindstones		450,000
Fibrous talc, short tons	41,354	389,196
Pyrites, long tons	111,836	273,745
Soapstone, short tons	13,670	232,390
Manganese ore, long tons	25,684	219,050
Asphaltum, short tons	40,841	190,416
Precious stones		118,833
Bromine, pounds	387,847	104,719
Corundum, short tons	1,970	89,135
Barytes, long tons	21,911	86,595
Graphite, pounds		77,500
Millstones		73,770
Novaculite		69,909
Marls, short tons	153,620	69,880
Flint, long tons	13,000	57,400
Fluorspar, short tons	8,250	55,328
Chromic iron ore, long tons	3,599	53,985
Infusorial earth, short tons	2,532	50,240
Feldspar, long tons	8,000	45,200
Mica, pounds	60,000	75,000
Ozocerite, pounds	350,000	26,250
Cobalt oxide, pounds	6,788	16,291
Slate, ground as a pigment, long tons	2,000	20,600
Asbestos, short tons	71	4,560
Rutile, pounds	400	1,000
Total non-metallic		$334,765,011
Add Metallic		307,334,207
Add Unspecified		10,000,000
Grand total		$652,099,218

MACHINE-SHOP NOTES.

Conducted by Albert D. Pentz.

DE GREE got the interchangeable mania and by working at home he tabulated all the regular sizes of the work made at Blunt's. He designed gages and special tools to inspect every cylinder, piston and crank-pin belonging to the regular stock and he had ideas left over for the special sizes of engines. Blunt was taken by surprise because he had not observed the preparations for this attack and therefore his guns were not trained in advance on the weak points of the plan. Hence De Gree got in this much of his oration before he was arrested:

"I have here, Mr. Blunt, a system of sizes and an arrangement of inspection and gages by which the work may be made to interchange perfectly, so that when an engine goes out of a certain regular size we will know just what the exact dimension of every part of it is. This system is in force in gun and pistol shops, in sewing-machine shops and I believe in locomotive shops, where the slight extra cost for excellence of workmanship in the parts is more than made up by the increased economy of setting up, assembling and erecting. In this shop, when a new piston is ordered for an old engine of our make we are obliged always to ask the bore of the cylinder even if we know the nominal size of the engine. Now the idea is to make the nominal size the actual size so that a ten-inch cylinder is bored out just ten inches and a piston for a particular size of bore will fit one cylinder of that size as well as another. The crosshead also——"

"Now Mr. De Gree," said Mr. Blunt, "before we get away from the cylinder let us consider the objections to your plan in connection with it so far as they occur to me at this moment. Suppose the casting for the cylinder will not bore out so small as ten inches, because in some cases the core expands under heat or sags so that the bore must be made larger to clean up. Shall we throw that casting away half done?"

"It might be better to do so, sir, in consideration of the saving effected in erecting where all the parts are alike."

"And after an engine has been run a number of years the cylinder requires reboring that would destroy the size at once, so you see that even should your plan be feasible here, and I am sure it would not, it would surely fail on the parts ordered for outside repairs. Now in this plan of yours for interchangeability, and in other plans of yours, I notice something that you have not spoken of. In every new thing you have proposed to do you go to work with more or less secrecy and plan the scheme out; and, when you think you have the thing in shape, you come to me with it. In the meantime you have devoted considerable attention and time to it. It is no matter whether you formulate your ideas here or at home, you have given to it attention in the shop and while your mind is on that subject it is on nothing else. It has happened that every one of the ideas you have thus far advanced has been discussed here and in all other shops many times before and many years before. If you had in each case asked a few preliminary questions and frankly stated what you proposed, you would have been set right, saved much work and ingenuity and would have impressed us more deeply with the idea that you desired to work in harmony with the rest of us. I am twenty-five years your senior, but I am glad to say that you have knowledge that I have not which is very valuable to these works. But if you give us the idea that you are working for a personal record; that you desire to point to an improvement as your idea rather than point to it as a benefit to the shop, and, instead of leaving your fame to justice and

to time, you attempt to nurse it unnaturally, you will neutralize all your valuable acquisitions and force us to resort to such reminders as this, oftener than is pleasant to either of us. You must believe that I am friendly to you and desire your service, and further I do not find you have this fault to a degree greater than other technical graduates. But like all other such graduates, who are without practice, you will find it best to teach and supply science and the theories only while you learn and assimilate practice and the arts of manufacture and management."

* * *

Simpson's jobbing shop is situated in a good location and in a thriving manufacturing center. Fifteen years ago he did a fine business, but ten years ago the steel-works got a tool-room of its own, and six years ago the harness-shop hired two machinists to do its work, etc., so that about all the good customers that Simpson depended on now are doing their own work and his shop looks deserted. Simpson blames everybody but himself for this state of affairs and everybody but Simpson blames him. You see Simpson "always liked good, reliable, steady workmen who took time enough to do a job right," and he always furnished them with tools to expedite the *time*. He charges by the hour—of course, all jobbers do that—and he has "no use for contract work." Now Simpson "really can't see wherein the great wheat crop of last year has helped this country very much."

* * *

Many of the difficulties in cleaning the sand off that has been burned onto large castings might be overcome by the use of a portable sand-blast. It is believed that thus better results could be got than are obtained on smaller pieces in the tumbler. This subject of casting cleaning, and in fact all foundry work, is a field for the mechanical missionary of vastly more profitable enterprise than the boiler and engine rooms are. Let a committee of the management be sent to every foundry that is operated for and in connection with a machine-shop, and let it be the first duty of that committee to ascertain how it is that the foundry can "kick" so as to be sustained against the shop nine cases in ten, and be wrong in ten. Then, next, find out why a change that is to save twenty per cent. in the cost of a piece, is successfully opposed if the foundry cost is thereby increased ten per cent. Then let them discover why one molder is permitted continually to make castings for a certain piece that weigh ten per cent. more than the average, and why another one always "cold shuts" a certain place no matter which pattern he uses. Then let them devise means to get the castings cleaned and inspected so that they will fit the fixtures without shop operations and so that no spiegeleisen or chilled spots in a casting worth ten cents shall ruin a gang of mills worth fifty dollars. If the foundry could be brought to compare with the machine-shop or with even the smith-shop in efficiency there would be an enormous saving made.

When molding-machines are perfected it will be a great event for the machinist who has to operate castings made in multiplicate.

* * *

When does iron shrink and when does it expand in cooling? Whenever we make a pattern for iron it must be one per cent. larger than the casting we expect to get from it, and the casting will be about that much smaller than the mold it is formed in. This indicates that iron contracts in cooling. On the other hand if we throw a piece of solid iron into a ladle of molten metal of the same exact kind, it will not only float but will rise perhaps ten per cent. above the surface and if it be forcibly immersed it will buoyantly rise again. This indicates that iron expands in cooling but when does it stop expanding and begin to shrink? This question when it is settled will lie still; but meanwhile there is a mighty interesting discussion in it.

* * *

In case-hardening, if bone be used, be sure it is dry, and pack the box full and solid. The causes that scale work are not always proved, but dampness within the box is bad as is air also. In quenching let the

parts have as little contact with the air as possible. It occurs to me that the scaling which occurs within case hardening boxes is probably the commencement of the "blister" which is characteristic of cementation in the making of old-fashioned steel. If this be so it is evident that the process either in temperature or time has been carried beyond practicability whenever the scaling occurs.

* * *

Cut key seats in shafts if they are to be round ended, not with an endmill, but with a "nibbler" made with a cutting-end flat like a drill with a reversed point; that is, instead of having a point at the center, have two lips one on each edge and let it be cut out in the middle. These two lips and each edge must be "backed off" so as to cut freely. Make the edges parallel to each other and you will have a tool which will clear itself of chips and which can be ground, when dull or broken, on an ordinary grindstone or wheel.

* * *

Every shop is benefited by having a good emery-wheel frame for an infinite variety of work; such as dressing castings and grinding soft articles to shape; but keep your men and boys away from it with their lathe and planer-tools. It is absolutely impossible to grind a tool on a swift dry emery-wheel and not draw the temper of the cutting edge. It may not be drawn three thousandths of an inch deep but the sharp edge after grinding is never as hard as it was before. The quality of steel in your tools will seem to get poor at once when they are ground on dry wheels. Shun them. A good grindstone is the best tool grinder because it cuts faster if properly watered, speeded, and covered; and it will not grind too concave. A wet emery-wheel, however, is very good and, as such are now made, they are quite convenient.

* * *

In boring a hole with a single-pointed tool in a piece that is attached to a lathe spindle and which is to be swung, if a machinist studies the question he will see that if he forces the chip toward the center of the hole it must turn a very sharp corner on the tool. In a smaller hole this fault gets worse. If, however, it be possible to grind the tool nearly square across the end and have room behind the point and between the stem of the tool and the hole, for the chip to pass down, and to back off the cutting edge so that it throws the chip back toward the tool post, then all sizes of holes may be bored as economically as outside turning is done.

* * *

McFadden's son, after he left the high school, went to work in his father's shop and began at the bottom. When he was twenty-four years of age he was a whole mechanic practically, but he often found that he had to go a long way about to get an apparently very simple mathematical calculation right, so he washed up, and took a course at a mechanical-engineering school. Now it was very plain sailing in that school for young McFadden. *He knew what it all led to.* He found here the links of theory which if placed between and within the links of practice that he already had, would make the chain a continuous one and he graduated with a sound mechanical training without any gaps.

* * *

One of the things which should be taught in technical schools is this: That theory without practice is absolutely a worthless commodity; that practice without theory is worth about fifteen dollars a week, and when both are well combined in one man of sound judgment the combination is worth up to ten thousand dollars a year. Let the mechanic, however, get his practical training first, and those who find necessity for a technical mechanical education should then take the technical course. A machinist at fifteen dollars a week when compared with a "mechanical engineer" who, for nothing, works under instructions in a draughting-room, presents practically a respectable appearance, and his chances for substantial advancement are fully as good. Few graduates have the courage to do the dirty work necessary to begin to get a sound practical training.

COMMENT & CRITICISM.

Civilian Engineers to Blame.

I AM much impressed with the justice of the rapidly-increasing volume of attack on Government Engineering. There is but the one word, "bad," that fitly expresses the situation, when the practical results of work done by the United States Engineer Corps is examined. In the April number of your magazine "Vox Populi" expresses fully, I am sure, the very general sentiment, and his words will find wide corroboration. The United States Engineers have no more business to be engaged in the building of canals, railroads and similar works, than an architect has, and they bear about the same relationship to a Civil Engineer as does the latter. They can be much more economically engaged, by devoting their talents to coast defenses, on which territory no civilian desires to enter.

One instance of the impropriety of their position I will cite: At the Pan-American Congress it was decided that a railroad to connect the Three Americas should be built, perhaps the most important project of the kind in the world. What did our great and enlightened rulers do? They placed the surveys in the charge of the United States Engineer Corps. Now, what, in the name of heaven, do these gentlemen know about surveying and building railroads? Every man of common-sense will endorse the proposition that such a great work, especially at its inception, should be intrusted to men who make engineering a profession, not to men who are practically amateurs, who employ civilian assistants to do the work, and take to themselves all the credit, when there is any.

The trouble lies as much with the civilian engineers as with the army men for the ridiculous situation. The absolute lack of unity and cohesion among them renders all efforts to cure such evils abortive. Professional jealousy, not only personal, but extending to the societies, renders it impossible for the American engineers to combine for mutual benefit, as do all other professions.

What rôle do the American engineers play as a body? None at all. Yet no one can question for a moment that if they would combine in one Central Engineering Institute they could have as proud a position in this country as the Institute of Engineers has in Great Britain, and could then, among many other needed reforms, retire the Army Engineers, from the places they usurp and fill with so little credit to themselves or benefit to the country, and to the great shrinkage of the public purse.

I do not agree with Mr. George Y. Wisner's "Plan of Reform." It is too complicated. The simplest thing to do would be to have the President appoint a commission of three prominent engineers, who should select a candidate from civil life to be appointed by the Executive as Chief Engineer, or any other title, and then let him select his own staff. That is simple, businesslike and what a big corporation would do. River-and-harbor appropriations would not then be so large.

T. WALN-MORGAN DRAPER.

New York, April, 1892.

Municipal vs. Private Control.

WHILE I am by no means a believer in the taking control by government, whether National, State or municipal, of any field of industry which can possibly be maintained an open field for competition, it does seem to me that Mr. William Nelson Black, in his paper in this magazine for April, is singularly unfortunate in selecting as arguments against municipal industry either the New York docks or the Brooklyn bridge. The former may not be as well handled as the municipal docks at Liverpool, but I fancy that he will not find many people to agree with his idea that they so far fall short of meeting the requirements of dock service on the

city water-front. It is perfectly true that a good deal of shipping has gone to the private docks in Brooklyn, but only because the warehouses are there; and the warehouses are in Brooklyn only because land values in New York, and especially on the water-front, are too high to permit of use for storing any goods whose bulk is large in relation to their value. When we go beyond this, we find that the Brooklyn system has been instrumental in building up a tremendous monopoly of warehouse and docking facilities that has been most fortunately avoided in the New York system, where there is at least something like a common chance for all.

As to the Bridge, there is no private enterprise that is exactly to be compared with it; but deficient as it may be for the enormous traffic that has been forced upon it, it is certainly not so bad as the Elevated roads. The Bridge management is to some extent responsive to public sentiment and public demands, if tardily so; with the Elevated, it is "the public be damned." Secure in a great and growing patronage, there is the most perfect indifference to anything but how that patronage will pay the largest net profit. Trains are run on a schedule nominally adapted to varying needs of travel, but in reality adjusted as nearly as possible to the smallest number on which the passengers can be crowded. In lieu of any real effort to improve facilities, we get nothing but the impudent demand for use of more public property for terminal purposes, on the transparent excuse that this will enable them to handle more trains, when there is daily evidence that they find no difficulty about handling enough trains to pack their tracks almost solid at any hours when they are sure of getting enough passengers to fill the trains. Their cars are not even comparable to the Bridge cars; their officials show about as well alongside the others; their train service is nothing like as regular or as fast. Even in such petty things as running cold cars on winter mornings because of the parsimony which forbids the keeping of an engine with steam up attached to the cars while side-tracked at night, to prevent the freezing of the heating-pipes, the same spirit is shown, of making the public pay as dearly as can be done for the monopoly which it has granted.

Reverting to the dock question again, if Mr. Black will glance across the North river to the Jersey side, where the essential requirements are the same as in this city, and not, as in Brooklyn, of a different character altogether, I think he will see that private control of water-front is not as admirable a thing as he has sketched. It has made the Stevens family in Hoboken very rich indeed; but it can hardly be said to have developed very greatly the private enterprise of any one else; and either the stockholders or the patrons of the Delaware, Lackawanna and Western railroad might tell him that even the all-powerful corporation cannot always successfully cope with the power in private hands to levy toll for access to a water-front.

E. J. SHRIVER.

New York, April, 1892.

What is a Fair Contractor's Bond?

I HAVE been much interested in your magazine, and especially in the recent articles on "The Rights of the Lowest Bidder." I have also been interested for some time past in regard to the bonds of a contractor. These bonds, as you are probably aware, are divided into two parts:

First. A preliminary bond, which is given by each of the several bidders at the time the bid is made, as a guarantee that the contract will be entered into to perform the work bid upon by the bidder. It is becoming quite a custom to have this bond consist of a certified check or a New York draft, and made payable to the bidder, and then endorsed by him in favor of the party for whom the work has to be done. This, it seems to me, is a good idea, but it should not be made too large; and my impression is it should not be less than $1000 or more than 2 or 3 per cent. of the estimated value of the contract.

Second. The bond given by the contractor that he will faithfully perform all the requirements covered by the plans and specifications, and his bid. The bond for this part of the work may be subdivided into several:

1. A probated bond, given by the personal or business friends of the contractor, a bond which is entered up against the bondsman, and becomes a lien upon his property until after the work has been performed, and the bondsman relieved. A bond of this kind is seriously objected to, because the bondsman usually gets no advantage from the contract if successful; but, at the same time, it ties up his property so that nothing can be done with it.

2. A bond given by the personal friends of the contractor. This is a bond on which no premium is paid; but like "1." is liable in case of failure on the part of the contractor. The friends of the contractor dislike, very much, to go on his bond, and, at the same time, dislike to refuse. It is equally disagreeable on the part of the contractor to ask his friends to go on such a bond.

3. A corporate bond, given by some Surety company, and for which the contractor pays a certain premium; depending somewhat upon the risk to be run, and the size of it. In this case, the contractor has usually to give an indemnity bond, or put up sufficient collateral, so that the Surety company is absolutely safe. This is objectionable, because where the bondsman has no friends to go on his bond, and then goes to the Surety company, other things being equal, he is at a disadvantage to the extent of the premium paid, and the use of the securities in the hands of the Surety company. It has often been argued in relation to this bond, also, that if the contractor has to secure his bondsman to the full amount of liability, he might as well secure his friends, and save his premium.

4. It seems to me that there is still a fourth class of bond, by which a contractor can be his own bondsman, and which, some years ago, was suggested by myself, and in one or two cases was tried, and was, I am informed, successful; and that is, that a preliminary bond consisting of a certified check first having been deposited, should not be returned to the bidder when the contract is signed, but held to his credit, and no money paid on account of the contract until the value of the work done shall equal some agreed-upon percentage of the estimated value of the contract. It seems to me that the amount retained should be about 10 to 15 per cent. of the value of the contract. After the value of the work done should equal this amount, then the full value of the work done thereafter should be paid to the contractor, as the work progresses, and the retained amount on the completion of the contract. In case this kind of bond is used the contractor himself will be the only loser, and he, in fact, becomes his own bondsman. On the part of the party having the work done it seems to me that it is safe, in that if due care is used in the selection of a contractor, this 10 or 15 per cent. ought to be enough to enable the work to be re-let or finished without any loss.

I have outlined some of my ideas on the subject, and I should be very much pleased if others, engineers and contractors, with the ability to write, should take up this question, and discuss the question as to "what is a fair, equitable and safe bond to be given by one party and accepted by the other;" a bond that will not be burdensome to the contractor, but will secure the ends for which it is given for the other party.

JAMES H. HARLOW.

Pittsburgh, Pa., April 2, 1892.

A Problem in Physics.

THE fourth law of permanent gases is as follows: "When a gas expands without doing external work, and without taking in or giving out heat, its temperature does not change." [See Encyclopædia Britannica, Vol. XXII, p. 480.] This law is based on Joule's experiment in which he allowed a compressed gas to expand into an empty cylinder and found that the temperature of the bath in which both cylinders were immersed was not changed. The result would have been more conclusive had the cylinders been in separate baths, though nearly all have adopted this law based upon the experiment. Some physicists consider that, at the first moment of expansion into the vacuum, there is no work done, but after that, the act of compressing the first flow of gas must require work; this is a fallacy, however. A second principle flows

directly from the same experiment. *The principal work done by a gas, as it expands into a vacuous or gaseous space, is that of imparting a velocity to its molecules.* We may illustrate as follows:

1. Consider a cylinder having an area of one square foot with a weightless piston midway in it. Lift the piston one inch by exerting a pull of about 180 pounds. We are taught that, since the outside air pressed upon the piston 2160 pounds and we have lifted only 180, the remaining 1980 pounds have been lifted by the air beneath the piston in its expansion. If this be a fact, we have discovered a remarkably easy method of multiplying energy. We need only to exert the pull of one pound on the piston and the air under it will do a work 2159 times as great. Is it possible to get any more work out of a system than we put into it? Has not the air under the piston, which was in equilibrium with that above it, simply restored this equilibrium disturbed by the pull, without doing any work?

2. Suppose the cylinder an inverted siphon, with a piston weighing 2160 pounds pressing upon the air in one leg, a perfect vacuum being above it. It is very evident that, though the air presses under the piston with a total pressure of 2160 pounds, yet, when the pull of 180 pounds is made as above in the other leg, the weighted piston descends a short distance but does no work.

3. This may be a little plainer if we consider each piston at the top of a leg of the siphon, both ends being closed. Apply a weight of 3000 pounds to each piston and they will descend a short distance, each having a perfect vacuum above. The slightest touch will disturb the equilibrium but the potential energy of the system will not be changed by the movement of the pistons and hence no work will be done.

4. Consider a cylinder closed at both ends and with a piston in the center. Place upon the piston pound weights one after the other until it has descended two inches. The air under the piston will be compressed and heated a certain amount. If we remove the weights pound by pound the air underneath will expand and do the work of lifting the weight, so that, when the last pound is removed, the temperature will be exactly what it was at the beginning, if no heat were lost in the operation.

5. However, if, when the piston had descended to its lowest point, we had suddenly removed the weight, the expansion of the air underneath would have occurred without doing any work, except that of imparting a velocity to its molecules, and hence the temperature would have remained nearly the same as left by the compression. The air above the piston in (4) did the work of imparting a velocity and its molecules as it expanded, but did no work when it restored the equilibrium. When the piston moved back, as the weights were removed pound by pound, the air beneath the piston lifted the weight we had put on, but, aside from that, it simply restored the equilibrium, or, in other words, we may consider it as pushing up a piston weighing 2160 pounds into the vacuum above it without doing work.

6. Inflate a balloon one-third full with hydrogen and just balance it at sea level. Remove a single ounce weight and the balloon will rise to a point where the pressure is ten inches and remain there. The gas expanding into a gaseous space did the work of imparting a velocity to its molecules, but did not overcome the resistance of the air. The gas would not have expanded at all had not the pressure been diminished, and, when that occurred, there was very little work needed to press out the sides out of the balloon into the free air, or restore the equilibrium. The present writer hopes soon to try a few experiments on this last illustration, and would be much pleased to receive suggestions from any of the readers of this magazine regarding the views here set forth. A full understanding of all the principles involved would much simplify the work of experimentation.

H. A. HAZEN.

Washington, D. C., April 2, 1892.

POPULAR MISCELLANY.

KITE-FLYING is an ancient sport, and has always been highly esteemed by the orientals. Among the Caucasian races it has been adopted freely by juveniles, and often by people of mature years. The Japanese and Chinese have developed a peculiar expertness both in the construction and flying of kites, making them to resemble birds, dragons, and other fictitious aerial animals. Our own great Franklin was the first to use a kite as a scientific apparatus. By its employment he proved the identity of lightning with electricity. This great scientific investigator and statesman was also fond of swimming, in which exercise he was very expert, and in his autobiography he tells how he used to join kite-flying with swimming, allowing the kite to draw him along in the water, sometimes, when the wind was strong, with considerable swiftness. Quite recently, in New York City, Dr. J. Woodbridge Davis has carried kite-flying to a high degree of perfection, having devised a way for guiding the course of kites in the air, and also having constructed kites, some of oiled silk and others of duck, of very large size and of great strength. He has also invented a folding kite frame, whereby during transportation a very large kite can be folded into a very compact space. This ingenious experimenter, instead of the single kite-string hitherto employed, uses three. Two of these are each attached by three short strings to opposite lateral margins of the kite, instead of bringing the three branch-strings from each side together and joining them to a single string. The third string is attached to the top of the kite. By tightening the cord attached to the left-hand margin of the kite, or what is equivalent, slackening the right-hand cord, the kite is made to describe a curve in the air to the left; reversing the manipulation of the cords of course reverses the movement of the kite, and by tightening or slackening the cord attached to the top of the kite, it can be made to take, and be maintained at any desired altitude. With kites of large size a wind velocity of at least twelve miles per hour is essential to their successful working, and at higher velocities the control of the kite is so perfect that it can be made to describe the forms of letters in the air; in this way it may be that a use may be found for kites in signalling. Such kites can also be used in carrying lines to vessels wrecked near a coast. Doubtless other valuable uses can be discovered for a kite that can be guided in its flight. Dr. Davis thinks that small boats may be drawn swiftly by such kites, and, with the use of a center board, may be made to sail into the wind. He has announced his intention to test this point experimentally. Should this turn out to be practicable, there appears to be no reason why the method cannot also be applied to the propulsion of sledges over smooth ice in arctic exploration as a substitute for dogs, the transportation of whose food adds much to the present limitations of sledge travel.

A Munificent Gift to the Trade Schools of New York City, described in the April number of this magazine, has been made by Mr. John Pierpont Morgan. Recognizing the great value of these schools, and desiring to perpetuate their usefulness, this eminent and wealthy citizen has donated to them no less a sum than half a million of dollars. It is to be hoped that Mr. Morgan's appreciation is shared by other wealthy and generous gentlemen, and that his example will be imitated. Of all the educational facilities the great city of New York can boast, it is doubtful that any are more worthy of public support than the trade schools. All occupations, not manual in their nature, are crowded to the doors, and the majority of young men can now gain a better livelihood in practising some mechanical trade than in any other way. They can, moreover, live healthier lives, and enjoy a freedom from care, unknown to professional men. From the trade schools young men are turned out fitted to engage at once in work at living

wages. Here is an opportunity to enter an apprenticeship without consulting the will of trade-unions, that has latterly excluded from shops many promising lads who were eager to fit themselves for future usefulness. Moreover, these schools are free from the petty jealousies and the narrow minded meanness which so often renders a boy miserable in a shop, and instead of helping him forward delights to throw all sorts of obstacles in his way. That such schools have supplied a growing industrial need is proved by their rapid growth and the avidity with which their benefits are sought. That their value is perceived by gentlemen of such intelligence as Mr. Morgan is a very assuring indication of future progress.

Sheet copper is now made by electricity in what is known as the "Elmore Process." To what extent this method may be made to take the place of rolling is as yet problematical, but the operation is extremely interesting as illustrating the almost inexhaustible leads opened up by progress in electrical science. In making these sheets the copper is electrically deposited on a mandrel in the same manner as copper is deposited upon surfaces in ordinary electro plating, the thickness of the shell or tube being exactly regulated. Then, either by the interruption or the reversal of the electric current, a coat of oxide is formed upon the shell, and upon this oxidized surface another shell is deposited. Finally the mandrel and the deposited shells, which before their removal from the mandrel appear like a single solid copper shell or tube, are lifted out of the tank, and the shells being cut longitudinally and flattened out, they separate easily into sheets. To those who have not seen the operation, it would seem somewhat difficult to make sheets of uniform and accurate gage in this way; but the *Electrical Engineer* (London) asserts that the thickness can be regulated with extreme accuracy. Of course the production of sheets, as described, implies the manufacture of tubes, but numerous other articles are also made, such as copper pots, kettles, steam pipes, rollers for calico printing, and cartridge cases. Wire is also made by cutting the sheets into strips and drawing the strips through dies. It is asserted that the economy of this method has now been carried to a point where a ton of copper can be deposited by the consumption of one ton of coal employed to generate steam for driving the dynamos.

The Utilization of Blast Furnace Slag as a material for bricks used in building, is said to have reached the point of paying a fair profit in England. The slag is reduced to the condition of sand by discharging it in a molten state into a shallow horizontally rotating tank containing from eighteen to twenty-four feet of water, wherein, instead of consolidating into a mass, the sudden cooling cracks it into fine fragments precisely as hot glass is shivered by contact with cold water. In the comminuted state it is scooped out of the tank by automatic machinery and loaded upon wagons, the scoops or buckets being perforated to allow the water to drain back into the tank. The principal location of the slag-brick industry is at Tees. The sand is also used in making cement mortar, for which purpose it is stated to be excellent.

The Sky Used as a Time Dial, has been shown to be capable of indicating the time to people over a wide area in the nighttime. The general features of the method are a clock and a reflector controlled by the clock by which a powerful beam of electric light shot up into the sky is made to move as though it were a hammer striking the hour. Of course this beam of light could be seen from a long distance. The invention has been recently patented in England. It is easy to see that many other indications can be made besides that of hourly divisions of time. The code so far adopted enables any minute of any hour to be indicated the first "beats" of the beam indicating even hours—then a pause—a second series of beats indicating five-minute intervals—another brief pause —and a third series indicating single minutes. Thus nine beats—pause—six beats—pause—four beats, would indicate 9 o'clock and 34 minutes. It is claimed that a standard clock could thus indicate time over an area having a radius of fifty

miles, or an extent of country of 7854 square miles. The inventor is said now to be making arrangements in London to test the method, time indications to be made every minute.

The Decay of Mechanical Skill, which is the direct result of modern shop methods, and the universal adoption of machine tools, and labor-saving machines, is as apparent as the collateral fact of the decay of artistic sense in workmen resulting from the gradual substitution of machine-work for hand-work. The writer recently needed some sheet metal work done in accordance with drawings prepared by him. Forty years ago there could have been found in any American village of two thousand population a tin-shop wherein this job would have been done at once and well done. After a long search, a good general worker of sheet metals was found who was willing to undertake the job; he was not found in a sheet-metal-working establishment, but in a shop where model machinery is a specialty. Such shops as these cull out from numerous applicants such as can demonstrate all-round skill in their respective trades. They are usually men well advanced in life. As they drop away, one after another, it becomes more and more difficult to supply their places. The decrease of manual skill and of artistic sense among mechanical workmen results not merely from want of such all-round practice as they got half a century ago, but from a want of that sort of loving-interest in their work the old-timers used to feel, when they could put something of their individuality into everything that they made. Nowadays the workman has simply to work out a design,—or rather, to run a machine to work out some part of a design,—prepared by some artist whom he does not know and never has seen. The general result may be beautiful when the different parts are assembled, but the workman feels that he has no personal share in the production of its beauty. He has become a regulator of a machine; he simply sharpens tools, adjusts them, keeps his machine oiled, and puts into it the material to be worked upon. All the precision, the nicety of operation are due to the *inanimate*, rather than the *living* tool. What interest can such work beget? What lofty ambition can it stimulate? What workman when the bell rings the time to quit work feels reluctant to leave his task, or lingers over it to bring out some beautiful effect or interesting combination that he feels he *must* see before he can depart contentedly? If machines were invented to play billiards, and only by their use could this king of games be played, how long would the game be a favorite? If violins could be performed upon only by automatic mechanism, or pictures painted only by machine-actuated self-charging brushes, who would be charmed any longer by art? Neither the artist nor the dilettante; the artist and the diletante would cease to exist. So, while we have gained much from the enormous increase in labor-saving machinery that has characterized the latter half of the present century, we have lost what probably will not soon be restored, the love of work and pride in work for its own sake, the love and pride that were the parents of mechanical skill; skill which, now they are dead, is itself decaying. The loss appears inevitable to those who scan the social horizon philosophically; it is, however, no less to be regretted because unavoidable. This tendency of labor-saving machines was many years ago pointed out by Ruskin, who, in the light of the fulfillment of his prediction proved only too true a prophet. It is this effect upon the masses, more than unequal distribution of wealth, that is separating society in America into distinct classes.

The Women's Building at the Chicago Exposition is to be decorated with sculptured figures from designs of Miss Alice Rideout, an artist said to be not yet twenty years old. This is an exemplification of the possibilities for women in the realm of art such as each passing year renders more numerous and conspicuous. There certainly ought to be an acknowledged field for women's work in architectural design as is proved not only by the above announcement, but also from the fact that the building destined to receive Miss Rideout's work has been designed both

generally and in detail by a woman. Certainly for reproduction of sketches, tracing, lettering, copying specifications, tinting, etc., a woman's delicacy of hand, and general accuracy of eye and touch, are natural qualities fitting them as well or better than men for such occupations.

Of Turbines as used in Switzerland to utilize the power of water descending from melting snow on the mountains, a very interesting account has been given by Prof. Forbes in one of the recent Cantor lectures before the Society of Arts in London. He stated that Switzerland was in the front rank as regards the utilization of water power, and that in "its transmission, whether by electricity or other means, the engineering talent of the country, compared with its population ranked higher than that of any other country in the world."

The towns of Geneva and Zurich attracted most attention. Owing to the melting of snow, the maximum flow of water in Switzerland was in summer. In Geneva, the River Rhone, where it leaves the Lake of Geneva is utilized. The fall varies from 6 feet to 12 feet. For this low fall it had been necessary to erect very large turbines. There were 20 turbines having a combined horse-power of 6000. This was a very large work, and involved a big capital expenditure. Switzerland, however, differed from a good many other republics, in respect that money voted for any particular work was really put into it. Engineering talent, combined with strict supervision over expenditure, had enabled this work to be done, and the enormous capital invested returned a profit. The way in which the turbines are utilized was to supply motive power to the factories which were distributed through the town, the watchmaking and other industries requiring a good deal of small power. The turbines pump the water up to a distant reservoir, three miles distant, which gives a large head of water, then from the pipe connected to the reservoir, pipes are laid through the town, and the motors thus supplied. The system was extremely effective.

Prof. Forbes thinks this method of distributing power might be economically imitated in numerous instances, particularly naming as a favorable location the heights, surrounding Edinburgh, Scotland. By adopting the methods used in Switzerland a large amount of power could be obtained and utilized for electric lighting or other purposes in the city.

An Artesian Well of Great Capacity is stated by *Indian Engineering* to have been bored at Lissington in Australia. At a depth of 1070 feet a vein of water was reached, when the water rose with such force as to carry upward a line of wooden poles more than 1000 feet in extent smashing them against the derrick head. An 18 cwt. sinker was thrown from the bottom of the well entirely out of the boring, together with gravel and stones that fell in a shower upon the ground. The water shot out of the well to a height of eighty feet from the mouth. It is estimated that from five to six millions gallons is the daily flow though, as yet, actual measurement has been impossible.

An Application of the Microphone to the detection of life in persons apparently dead, is shown to be feasible by an experiment recently performed by a Russian physician in St. Petersburg. A woman who had fainted and whose pulse and respiration had apparently ceased, was demonstrated to be still alive, after a statement by another physician that she was dead and that she had died from paralysis of the heart. The use of the microphone over the heart disclosed the fact that the heart was still very feebly beating, and a persistent effort resulted in restoring the woman to consciousness.

An Artesian Well in Australia having been bored to a depth of 1070 feet, water was suddenly struck, and the flow commenced with such force as to drive 1000 feet of wooden poles out of the boring and smash them against the head of the derrick, and also to project from the bottom of the boring a sinker weighing nearly a ton. The water has since been spouting from the well to a height of 60 feet above the surface. This indicates a pressure at the bottom of the bore of 460 lbs. per square inch.

A New Method of Slaughtering in Abattoirs is now proposed, being no other than the killing of beeves, etc., by electricity. This being seriously proposed as a more humane method than that now

practised, its humanity is likely to be disputed and the method opposed by the same class of cranks that has made such an ado about electrically executing criminals. Surely, if a man can be tortured so can a beast. Herein is opened a wide field for the exercise of surplus sensibility, and we may expect to hear numerous protests against the barbarous practice.

A Purer Chloroform than has yet been available and which by virtue of its purity is claimed to be produced by the Swiss scientist, Pictet, by a process of artificial refrigeration that precipitates a quantity of deleterious impurities. It is moreover claimed that the physiological effects of the impurities removed by Pictet's process when isolated have been such as to show their deleterious quality beyond doubt. If this be all as stated, the use of chloroform in surgery, the benefits of which are simply incalculable, may become free from some dangers hitherto attending its administration. The use of intense cold for purifying and separating chemical substances is still in its infancy, though for the extraction of menthol and similar substances from essential oils it has been for some years employed.

The Murata Repeating Rifle is the name of a new arm said to be now manufactured by the Japanese Government at the Koishikawa Arsenal at Tokio. The new weapon is said to be about three feet six inches long inclusive of the stock, of light weight, and capable of firing ten shots without reloading. With smokeless powder the weapon is said to have power to pierce three plates of steel one-eighth inch in thickness at a distance of 300 yards. Further improvements upon this yet unsatisfactory arm are to be made.

Teak Wood, on account of its color, its durability, hardness and strength, is increasing in its applications and in demand throughout the civilized world. Exposed to weather, it withstands the action of the elements better than most other woods, and hence has come into great favor with shipbuilders for the construction of deckhouses, etc. However, according to the *Journal of the Society of Arts*, the end of the supply of this valuable timber is in sight unless measures be adopted to limit the destruction of teak forests now going on. The natural home of the tree is "in Central and Southern India, Burmah and Siam. At present rates of cutting and waste, it is asserted that twenty years is the longest period (some say ten years) allowed by best authorities for the exhaustion of the forests, unless systematic action be exerted for the cultivation and preservation of the timber. Meanwhile, the increasing difficulty and labor of getting the timber and delivering it at commercially practicable points, must inevitably raise the price and tend to diminish its use. It is in Siam more notably that wasteful methods prevail. No effort is made to renew the supply by planting, and young saplings that would otherwise help to maintain the supply are either destroyed by forest fires, or their growth is interfered with by other causes, neglect being everywhere the rule.

A Novel Foundation has been described in *Indian Engineering*. In making this foundation, a hole is bored in the ground (which was previously damp) from 10 to 12 feet deep and 1½ inches in diameter. Then this hole is charged with cartridges which being exploded not only excavates a hole 3 ft. in diameter but drives the water out of the earth surrounding the excavation to such a distance that it does not filter back for more than an hour, meanwhile the excavation is filled with quick setting concrete which by the time the moisture returns is hardened enough to hold up against the water. In this way a series of foundation supports for a building may according to the journal quoted be very rapidly formed.

A Scheme for a Technological Institution in Chicago is on foot with considerable probability that it will be carried out. Chicago is not content to be behind other large cities in this particular, and several of its leading daily newspapers have editorially supported the project. A paper on the subject was recently read by Mr. Francis W. Parker before the Chicago Electric Club, in which the establishment of such a school was earnestly advocated with no lack of good reasons.